LONDON SHOW REVIEW

AUTOMOBILE ENGINEER

27 NOVEMBER 1961

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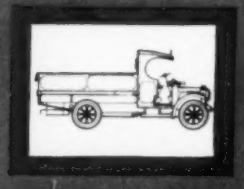

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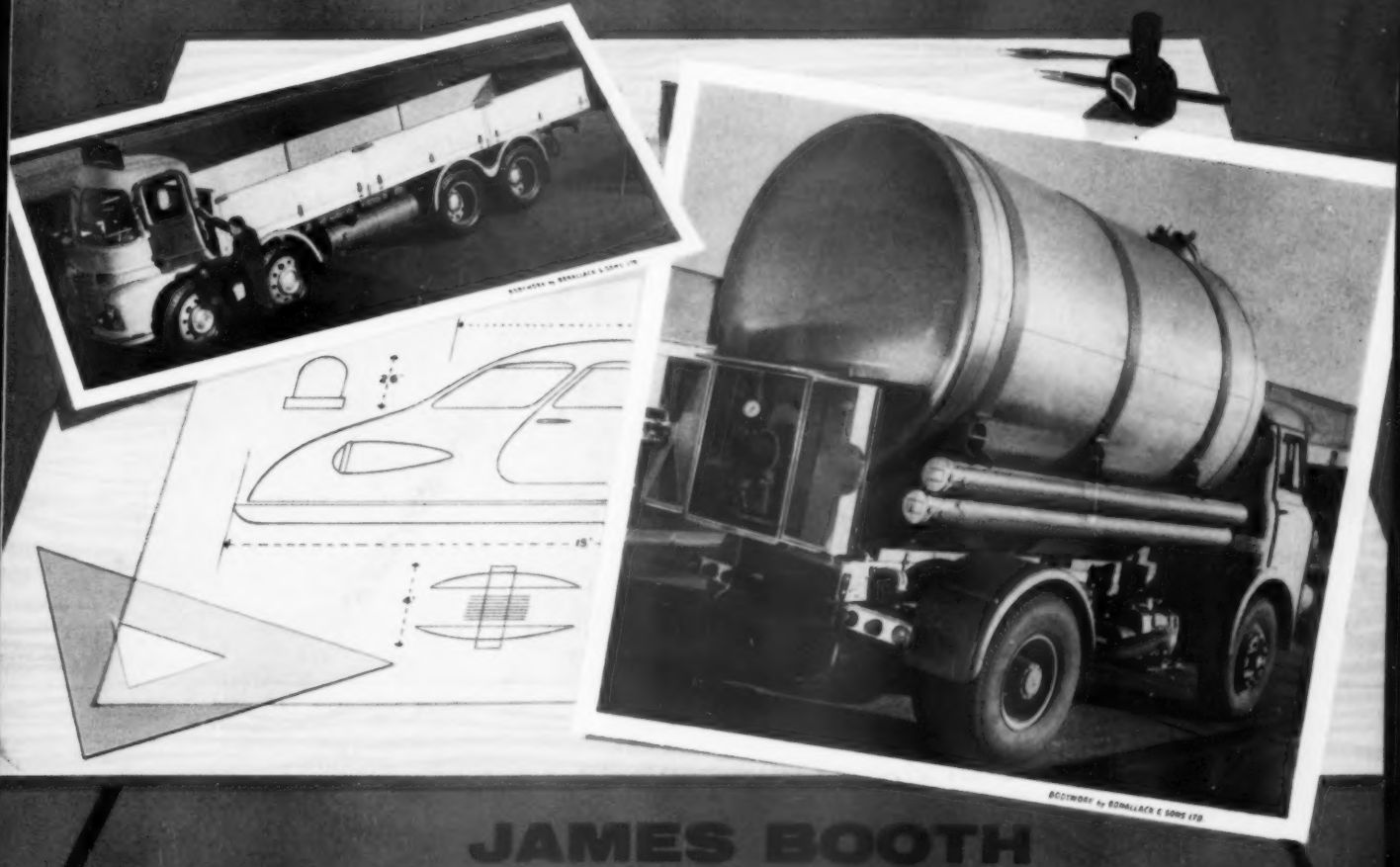

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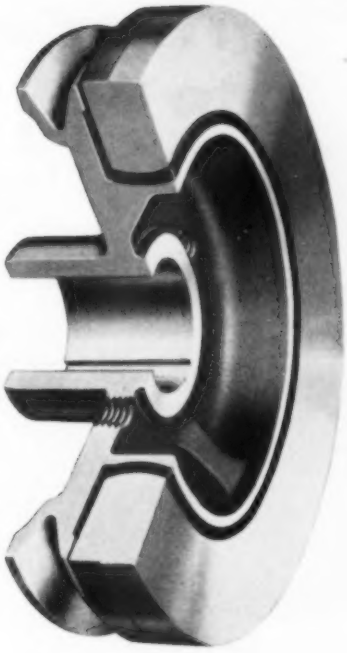

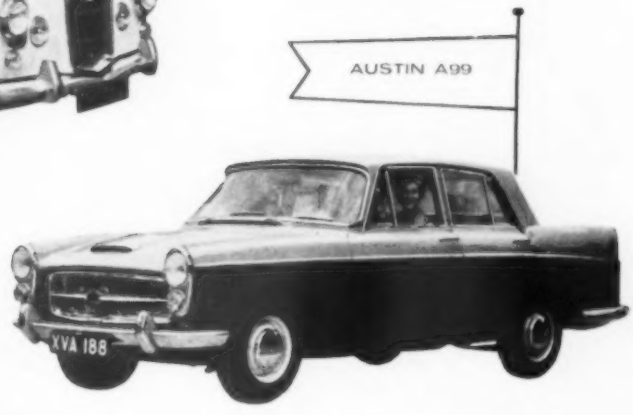

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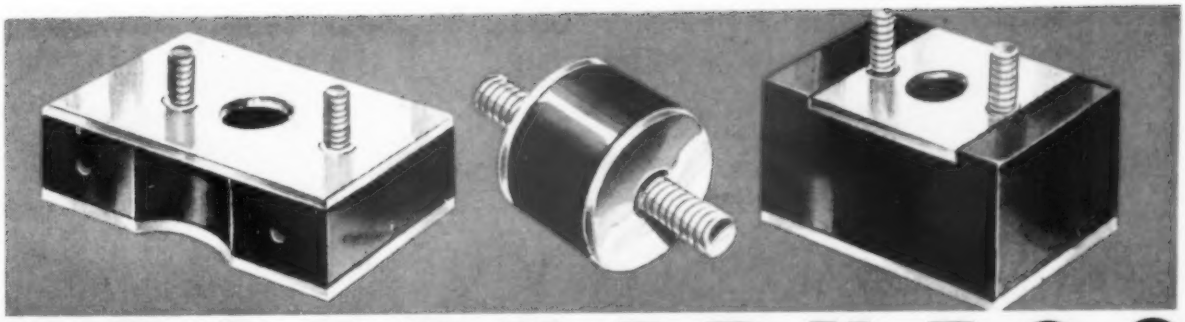
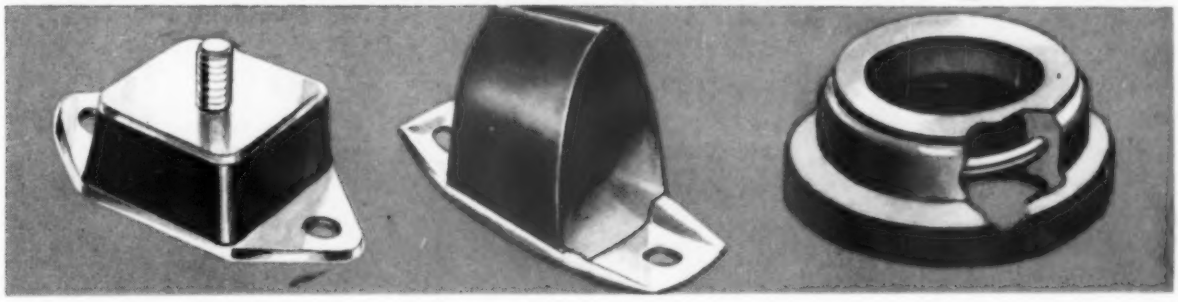


TOGETHERNESS

in rubber and metal



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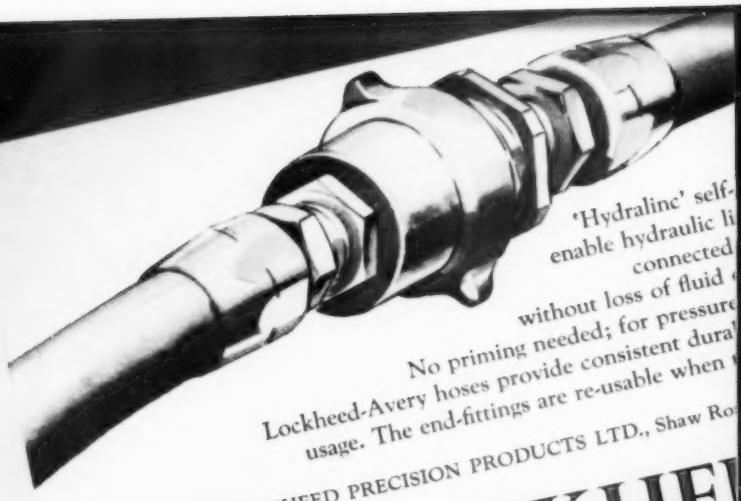

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without loss of fluid
No priming needed; for pressure
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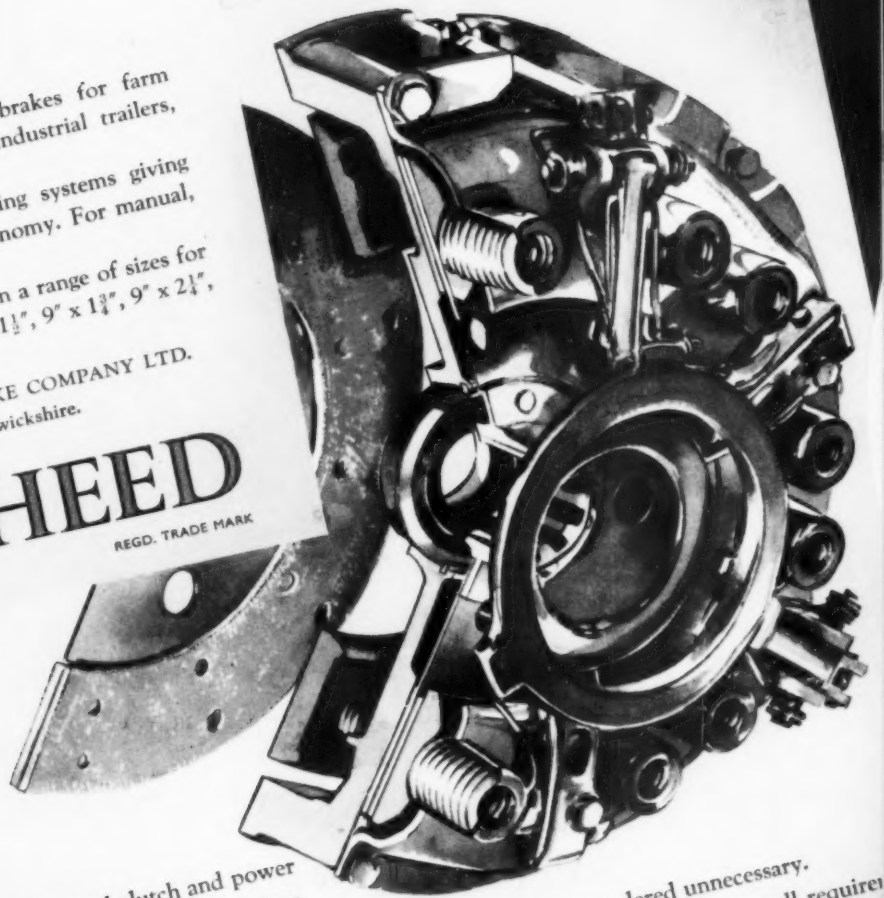

The integral clutch and power take-off for tractors comprises two clutches mounted in tandem; in most cases a separate engine for driving implements is rendered unnecessary. In addition there is an extensive range of Borg & Beck clutches covering all require also a wide range of Rockford over-centre clutches and power take-offs. May our representative call and discuss your problems?

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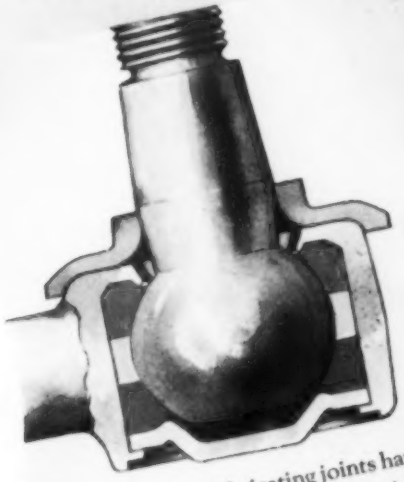

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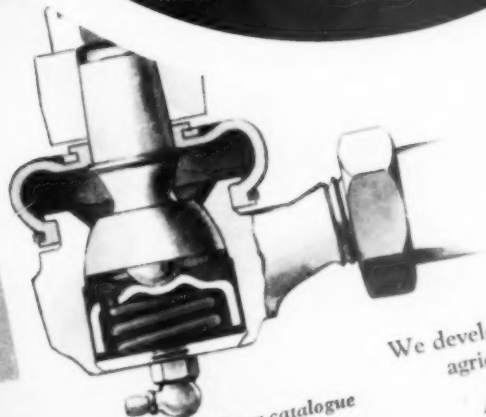
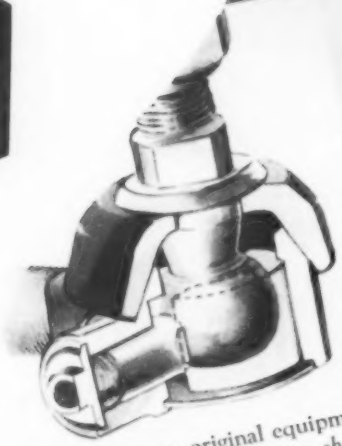


May we send our catalogue of standard joints?



Thompson steering joints withstand the continual hard wear imposed by the operation of tractors over rough ground, they are self-adjusting and free from the need for constant maintenance and adjustment. We develop joints for use on original equipment, to suit all requirements of the agricultural industry. *This illustration shows one of our special purpose joints.*

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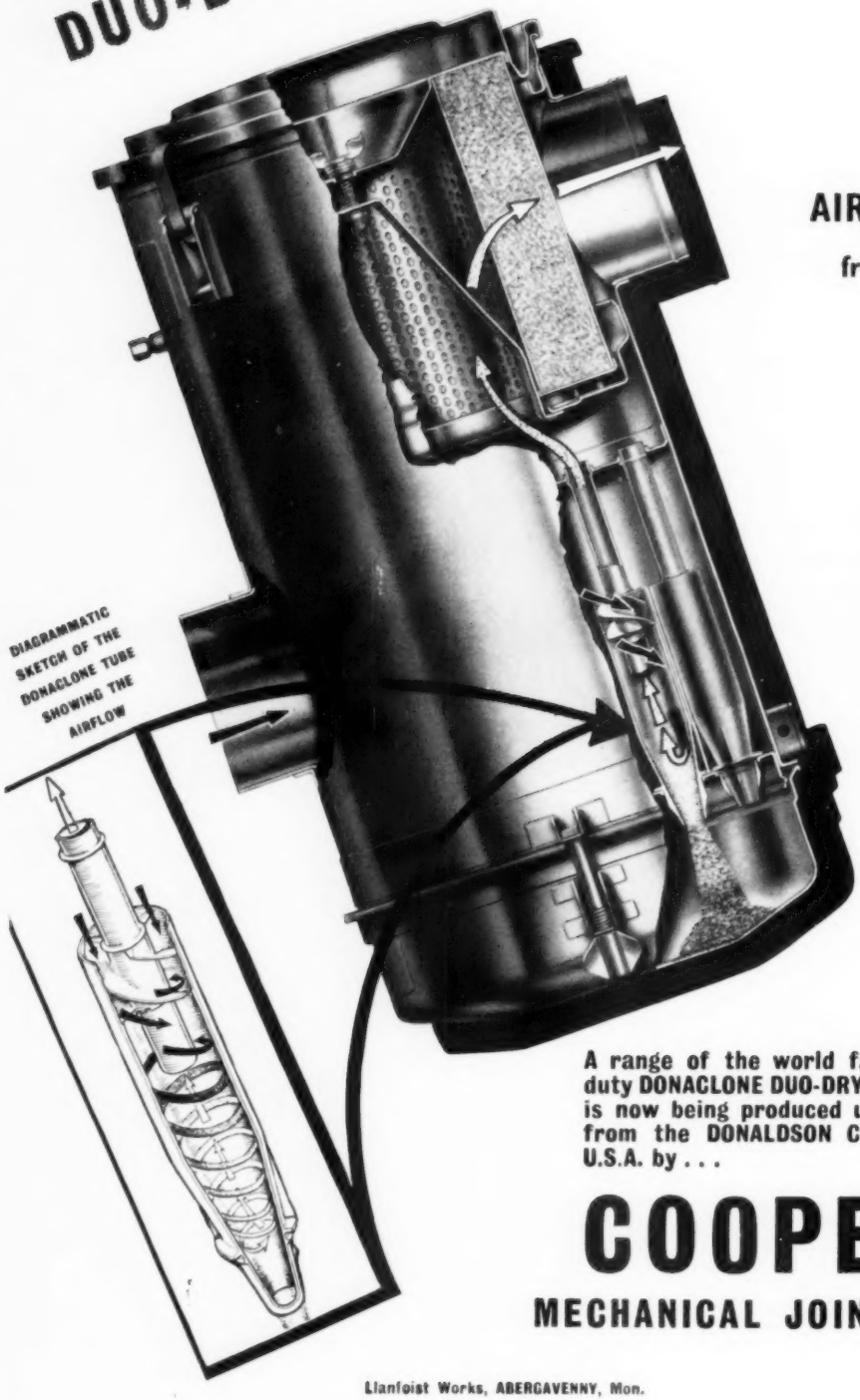

DIAGRAMMATIC SKETCH OF THE DONACLONE TUBE SHOWING THE AIRFLOW

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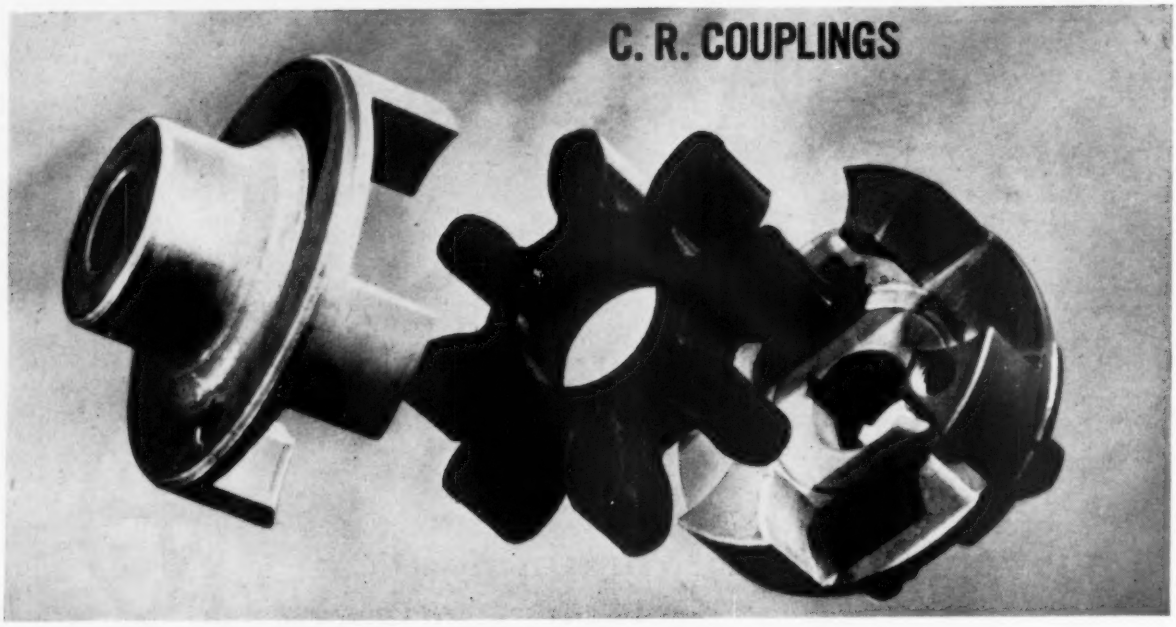
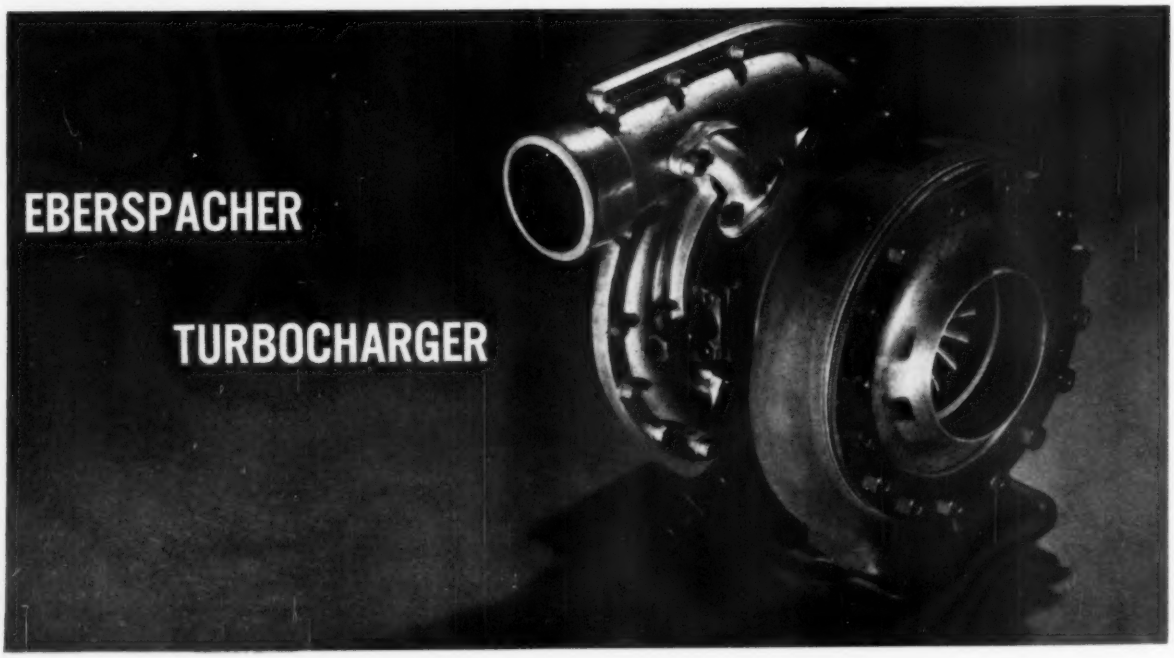
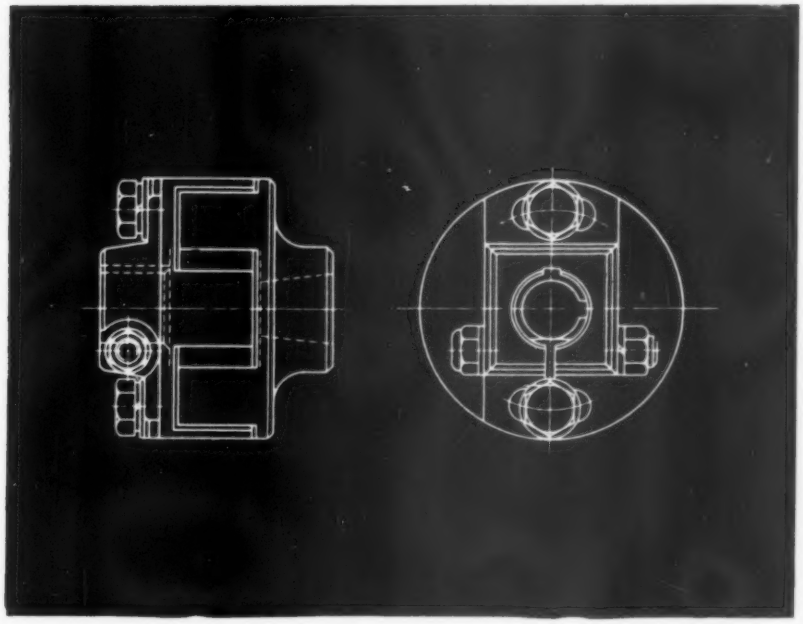
Simms are the largest manufacturers of British



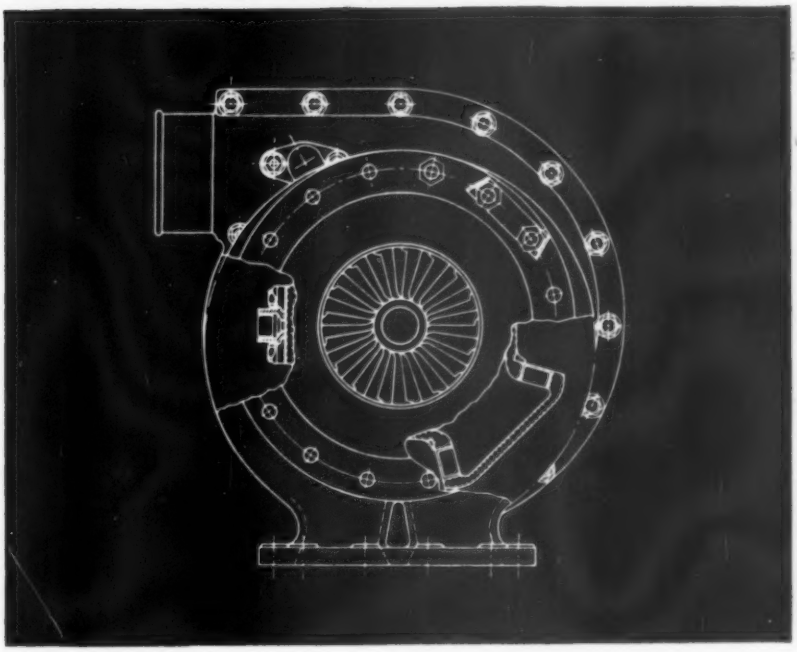


Simms

designed and built fuel injection equipment



Simms C. R. Couplings are silent. They will accommodate small misalignment without wear or chatter. Any flexing takes place within the resilient insert—not by sliding. This insert is of Nitrile synthetic rubber which is impervious to oil (eight times as good as Neoprene). The coupling cannot be incorrectly re-assembled. Consequently accurate timing of driven equipment is maintained.



The Simms-Eberspacher Turbocharger uses waste heat energy in exhaust to provide more air for combustion; hence it enhances the power output from a given cylinder capacity with higher overall efficiency. Turbocharging increases flexibility; reduces smoke and the effect of altitude variations on engine performance.

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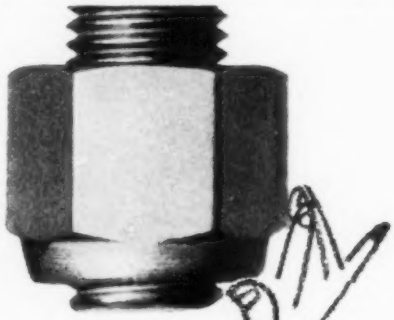

** These times are based on 'The Handbook of Standard Time Data for Machine Shops' by Haddon & Genger published by Thames and Hudson Limited, London.*

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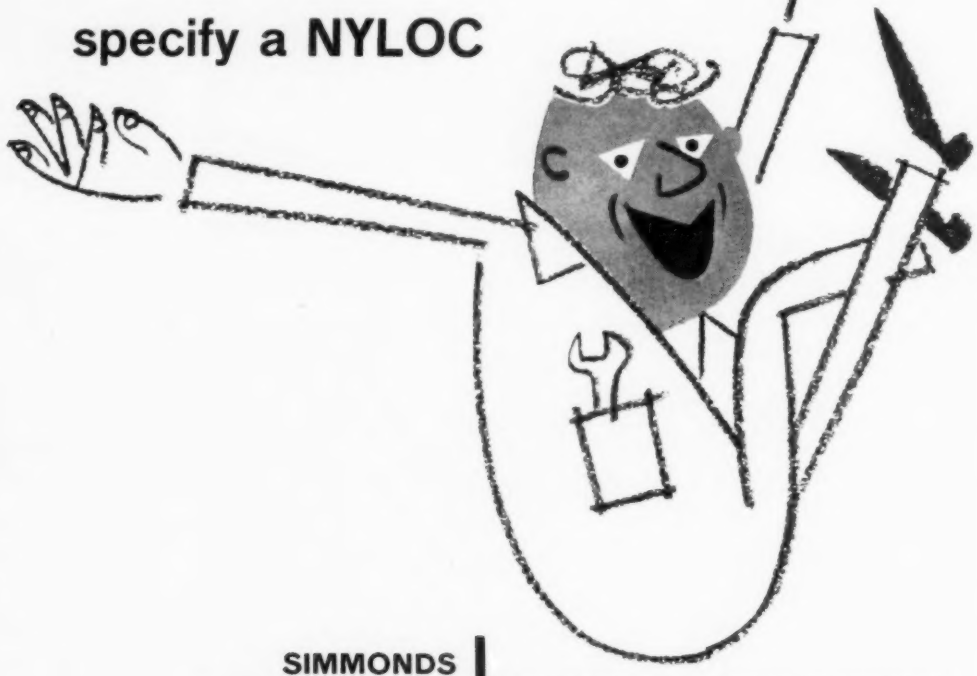

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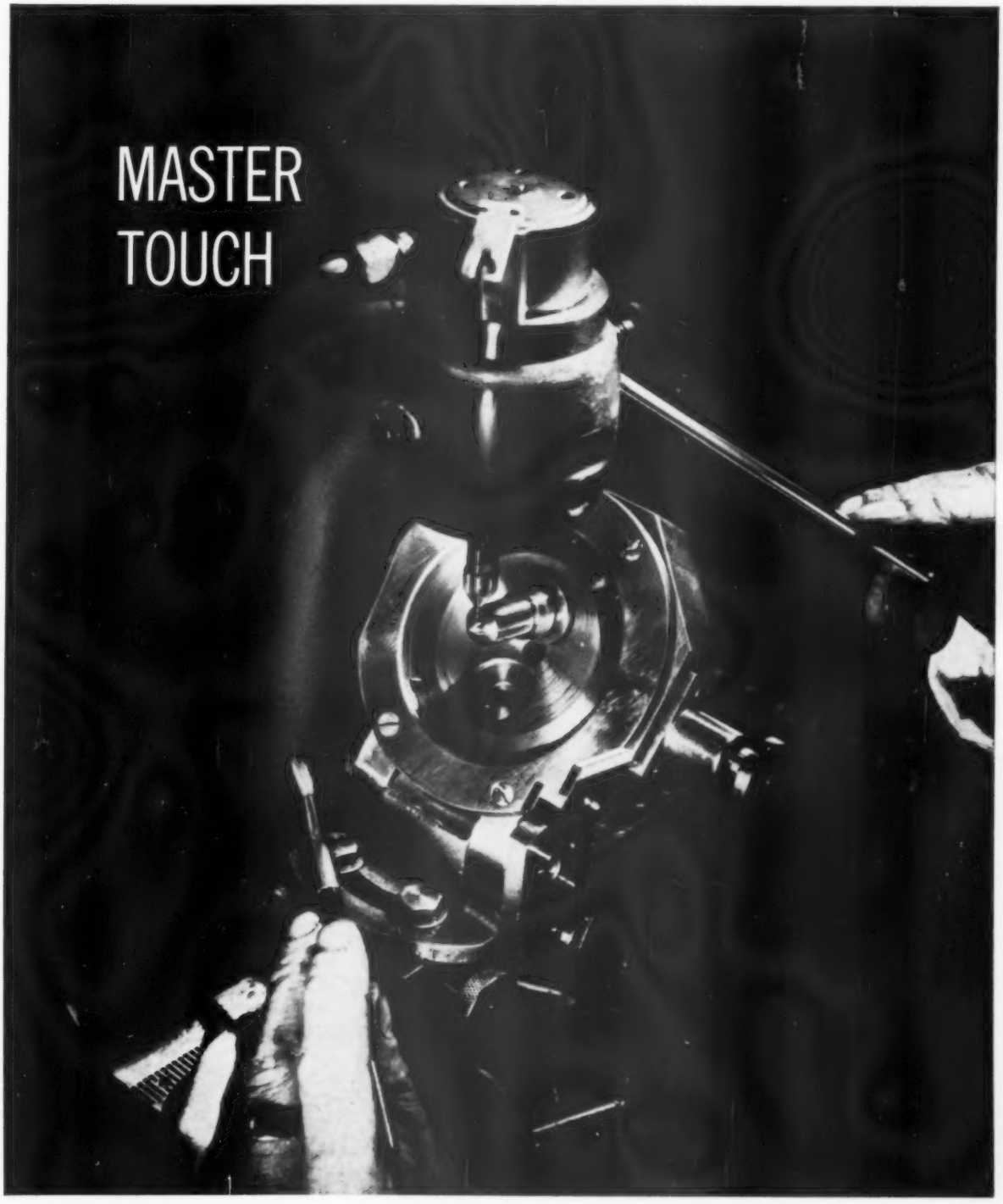

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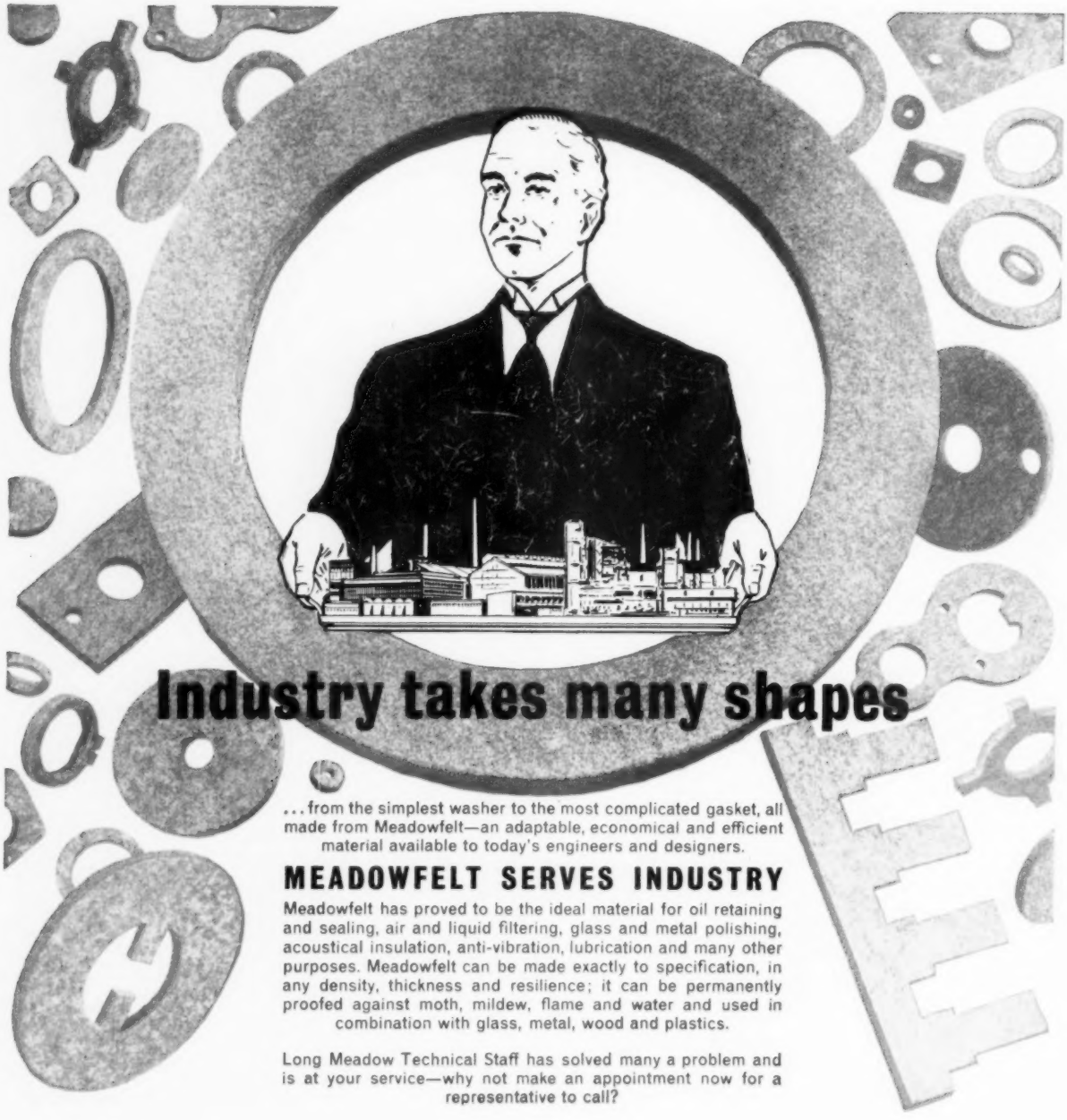

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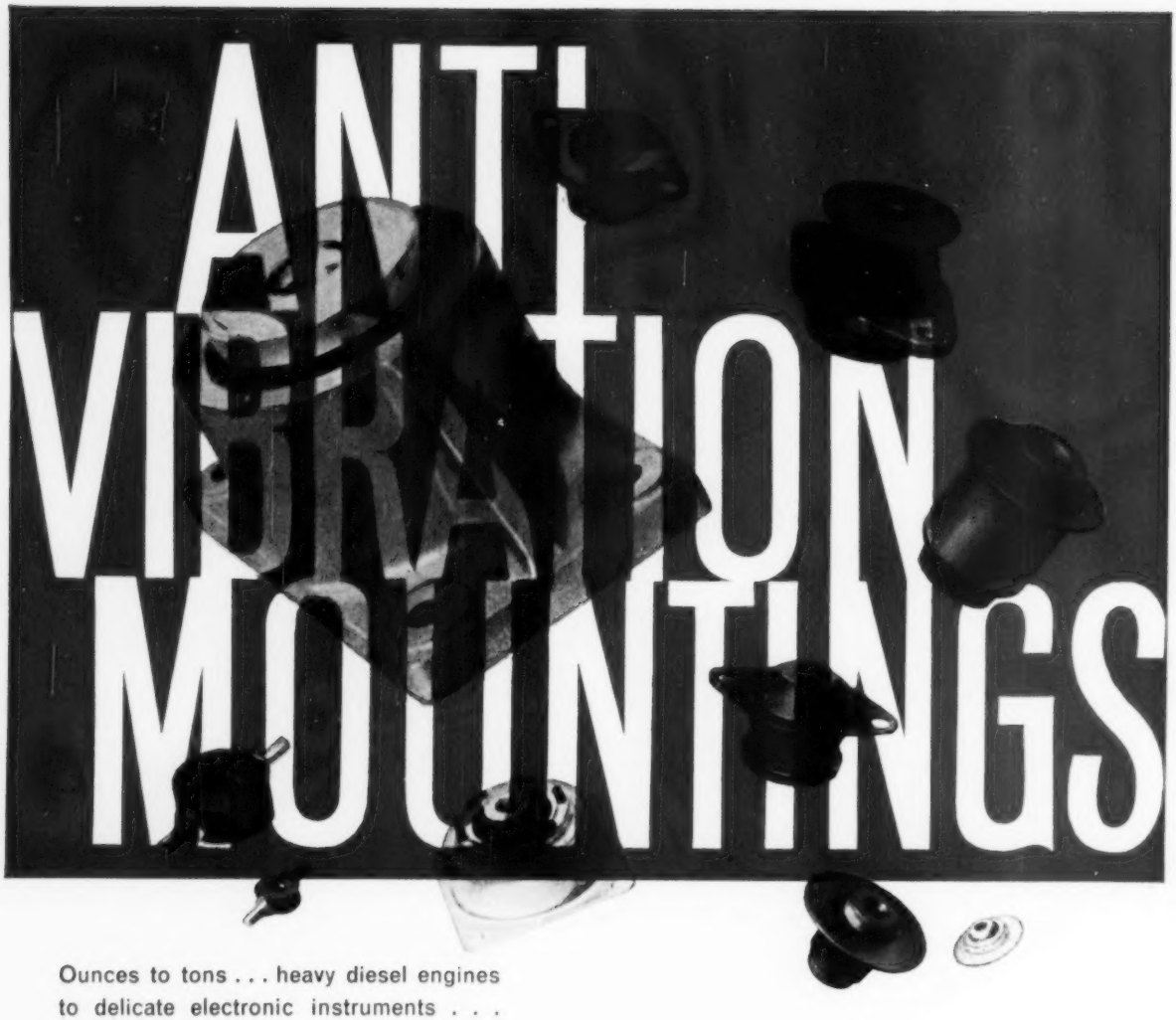

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■ Du Pont neoprene is chemically stable and will dissolve in solvents and solvent mixtures to give adhesive solutions of varying viscosities and drying rates. It can be compounded to form the ideal adhesive for an almost limitless range of materials. For leathercloth in particular a neoprene-based adhesive is recommended. It will not weaken with age or degenerate under those extreme conditions of weather to which exported vehicles are often subject. Bonds effected by solvent adhesives based on Du Pont neoprene are also highly resistant to degradation by oils, chemicals and water, as well as heat, sunlight and ozone.

■ To find out how adhesives based on Du Pont neoprene can solve *your* bonding problems, send the coupon below for further information and list of suppliers to the Du Pont Company (United Kingdom) Ltd., 76 Jermyn Street, London, S.W.1.

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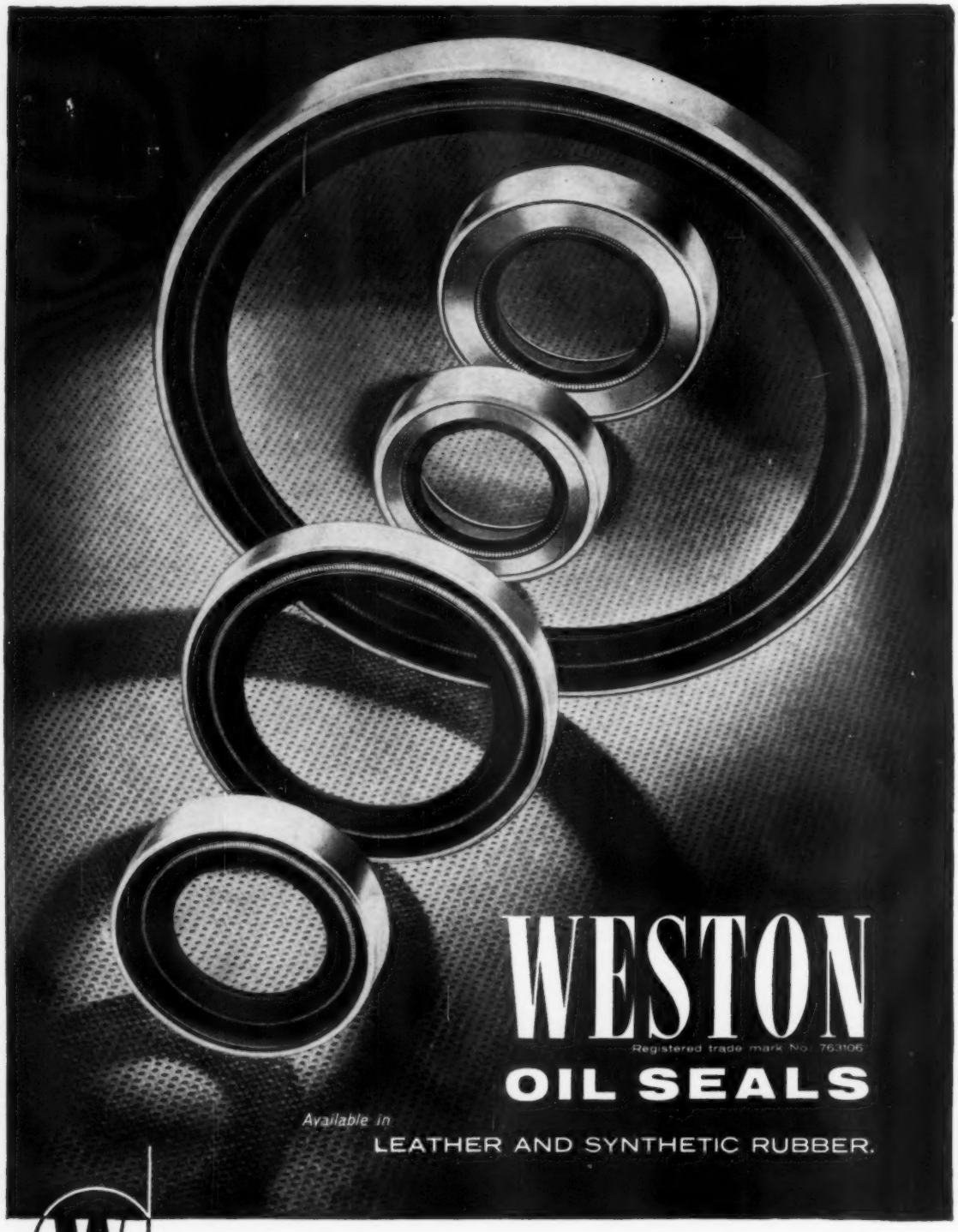

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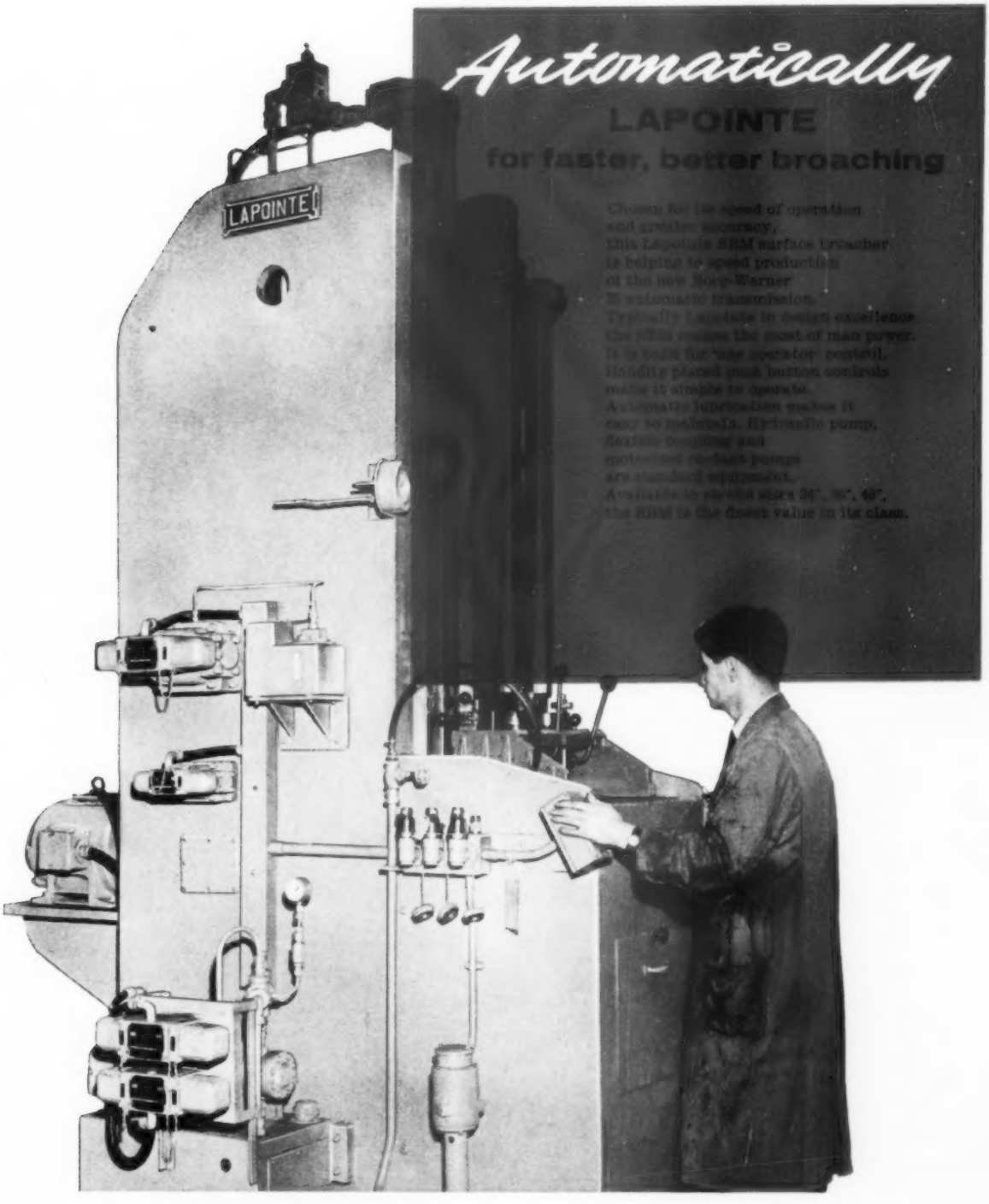

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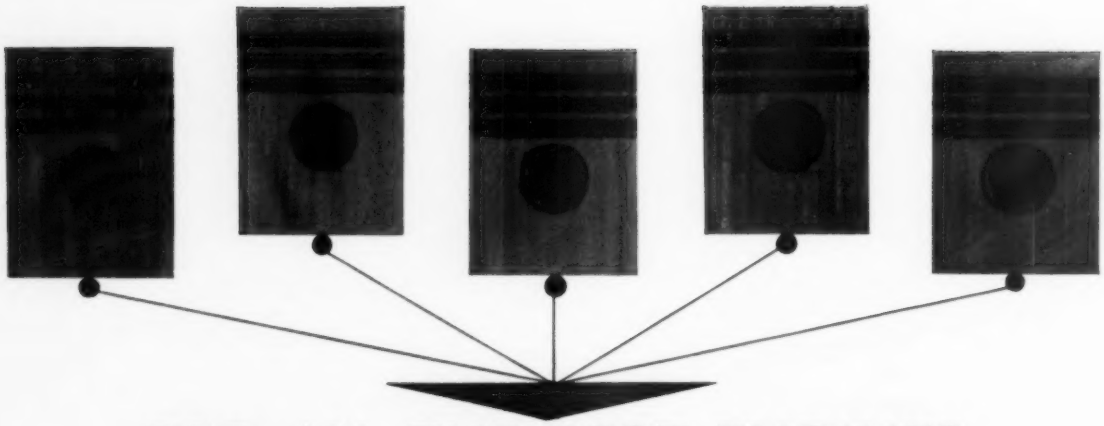

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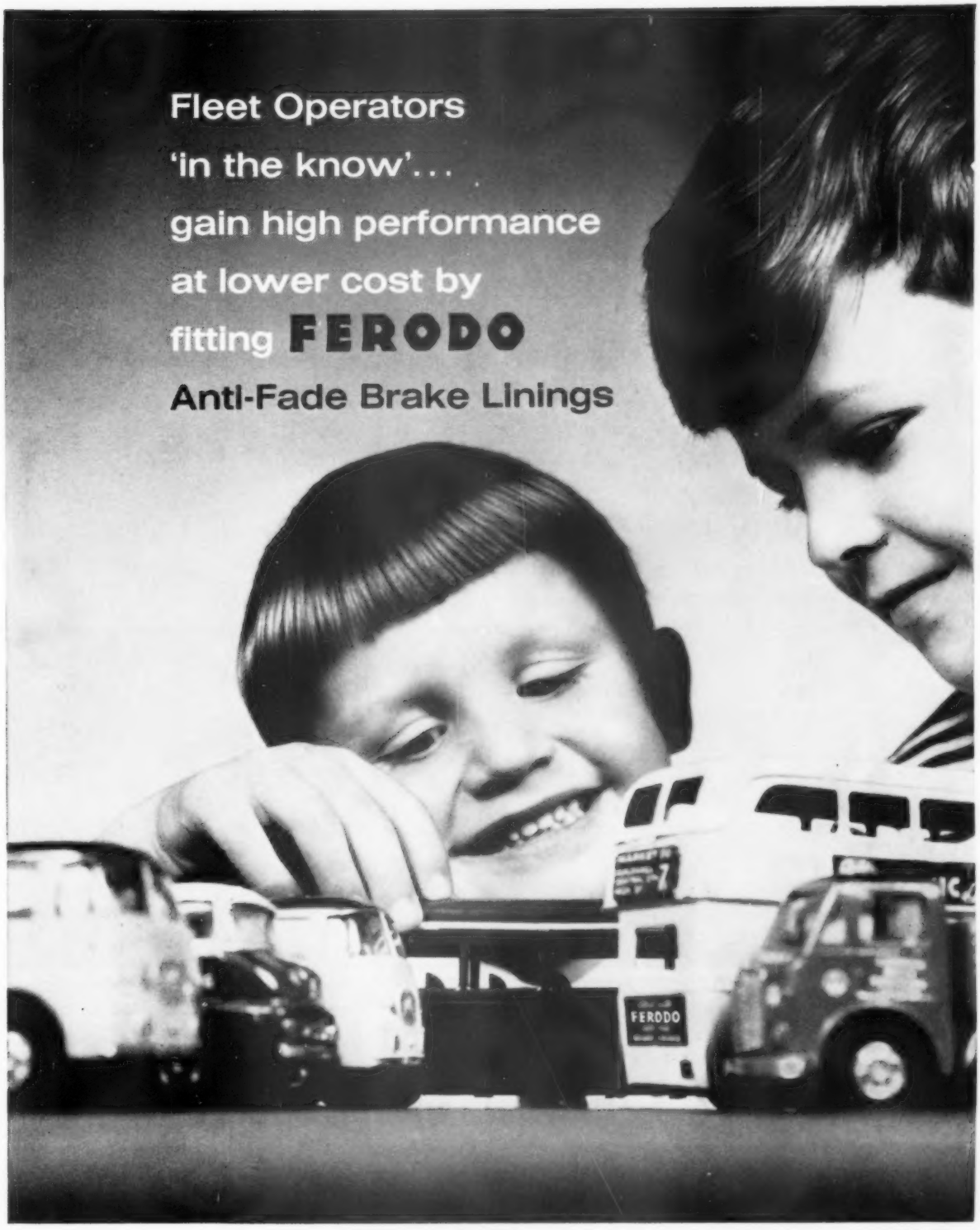

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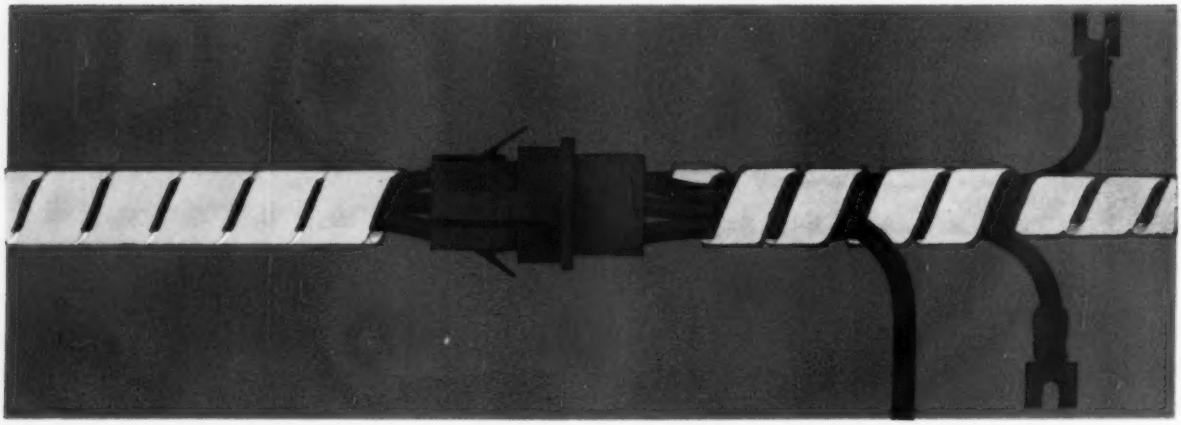

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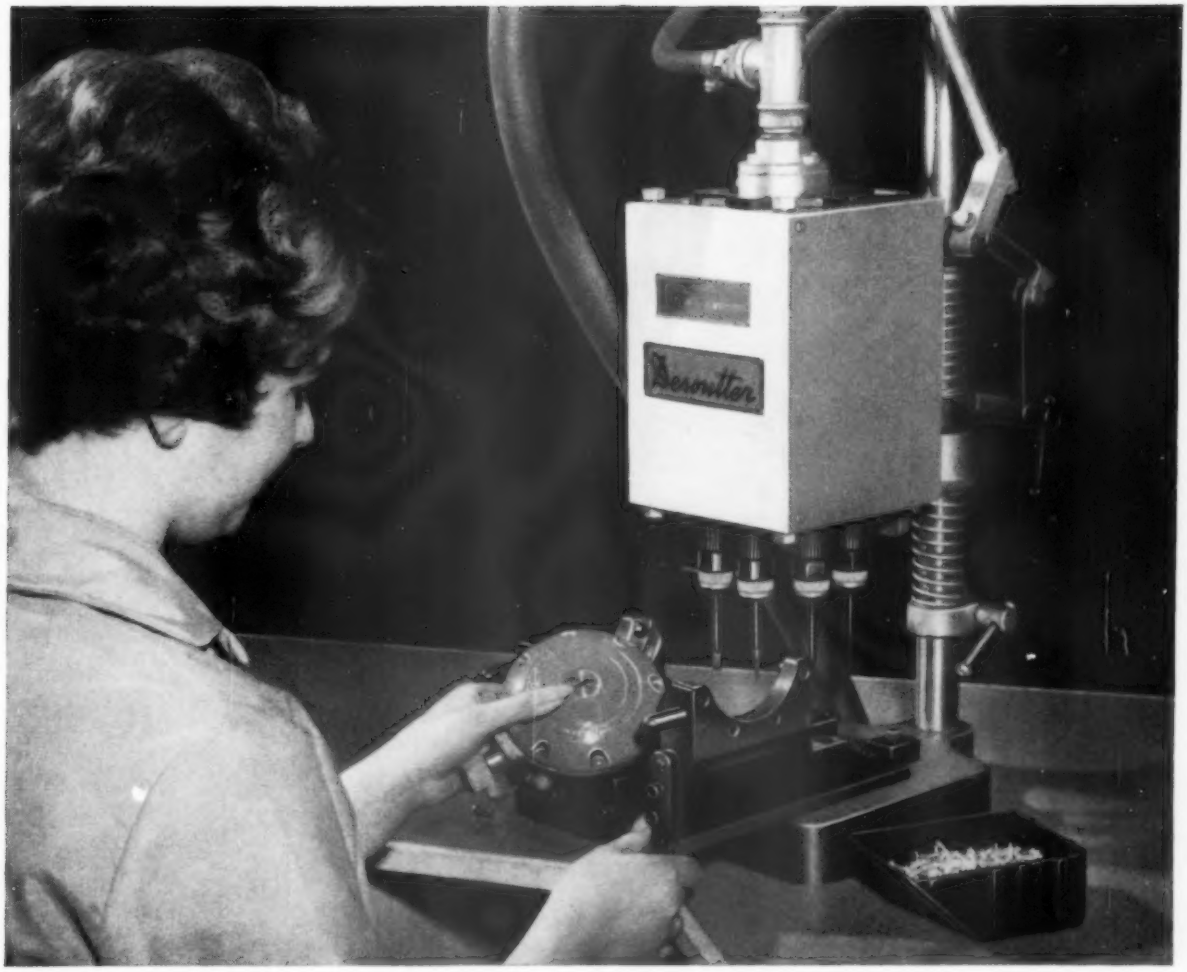

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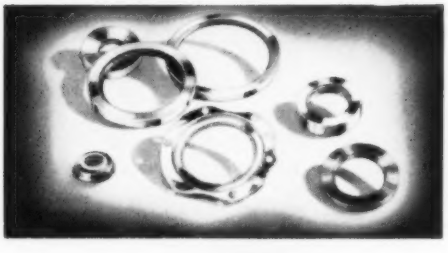

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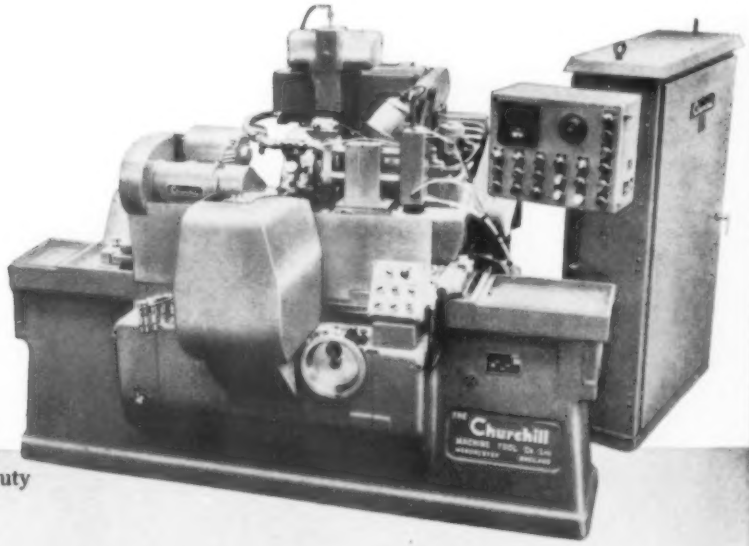
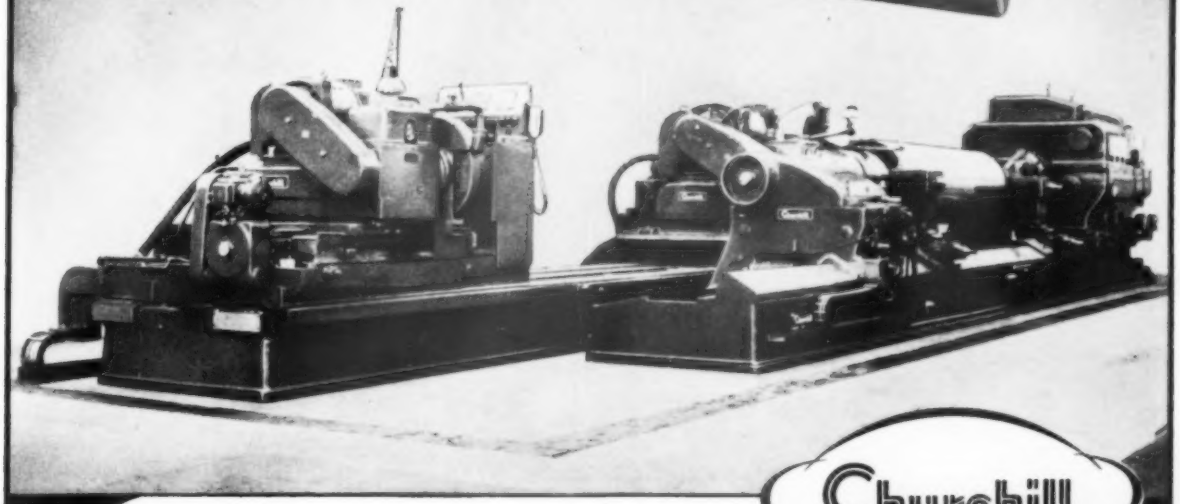


Model "TWR" 72in. x 360in. Heavy Duty Roll Grinding Machine



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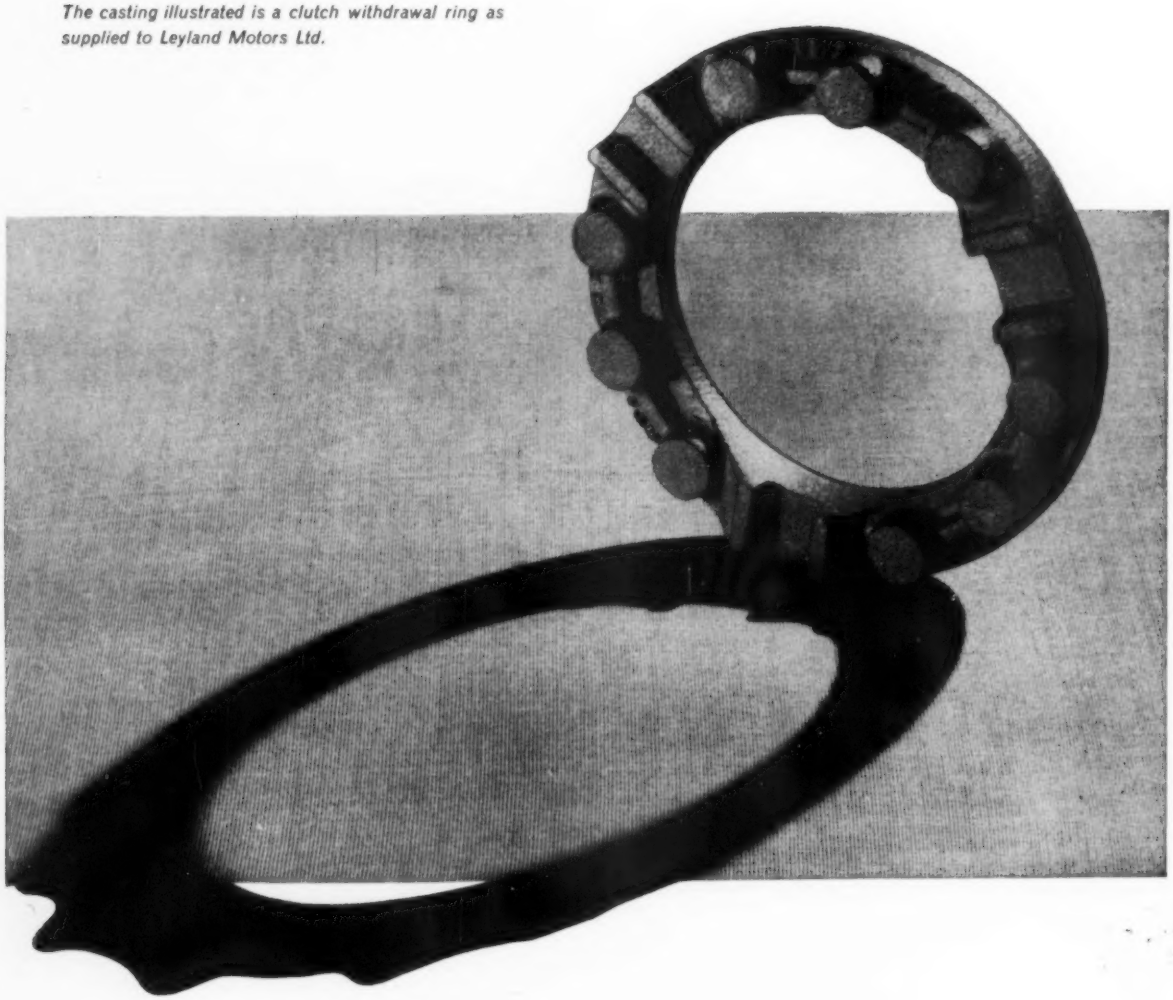

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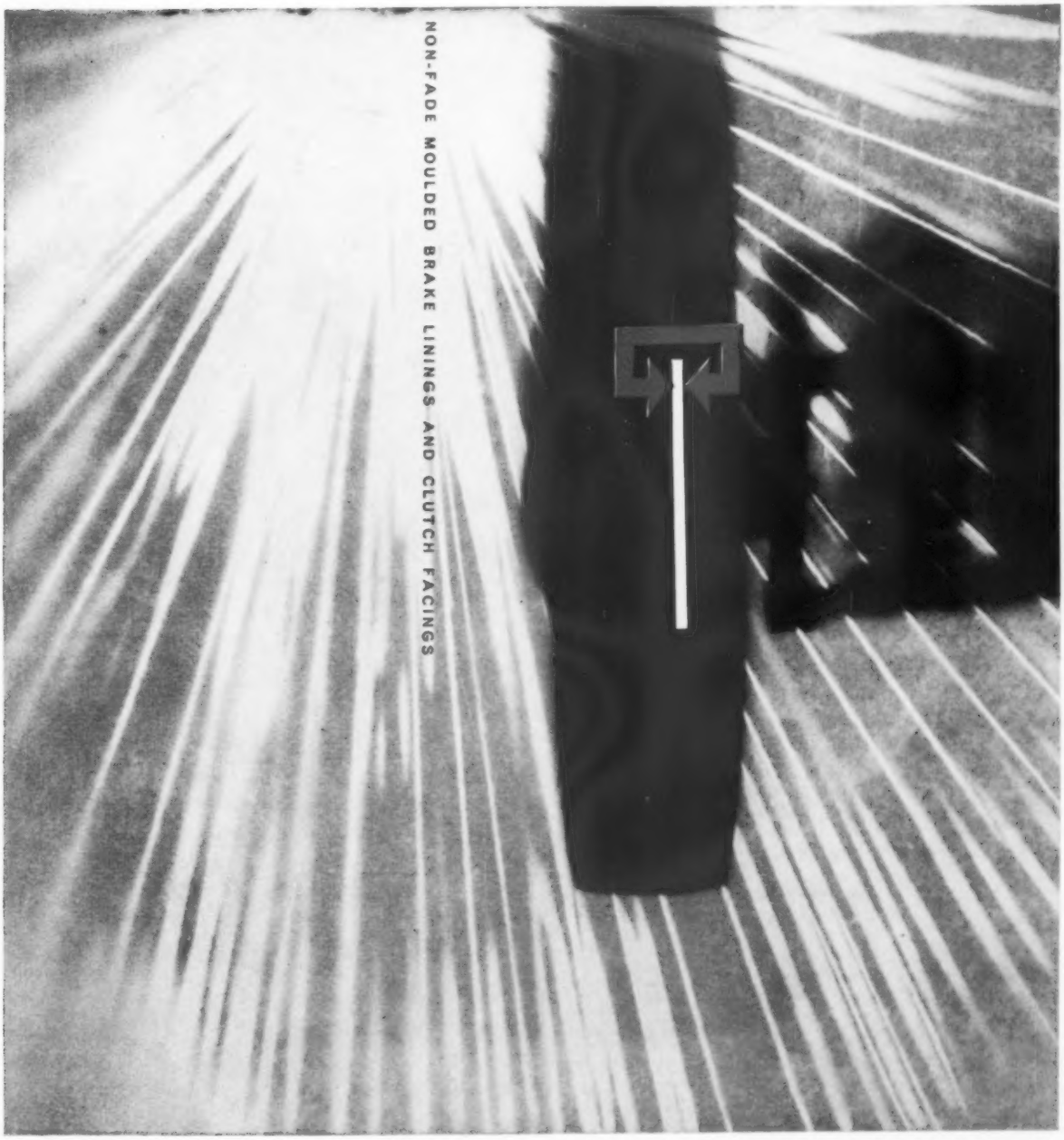

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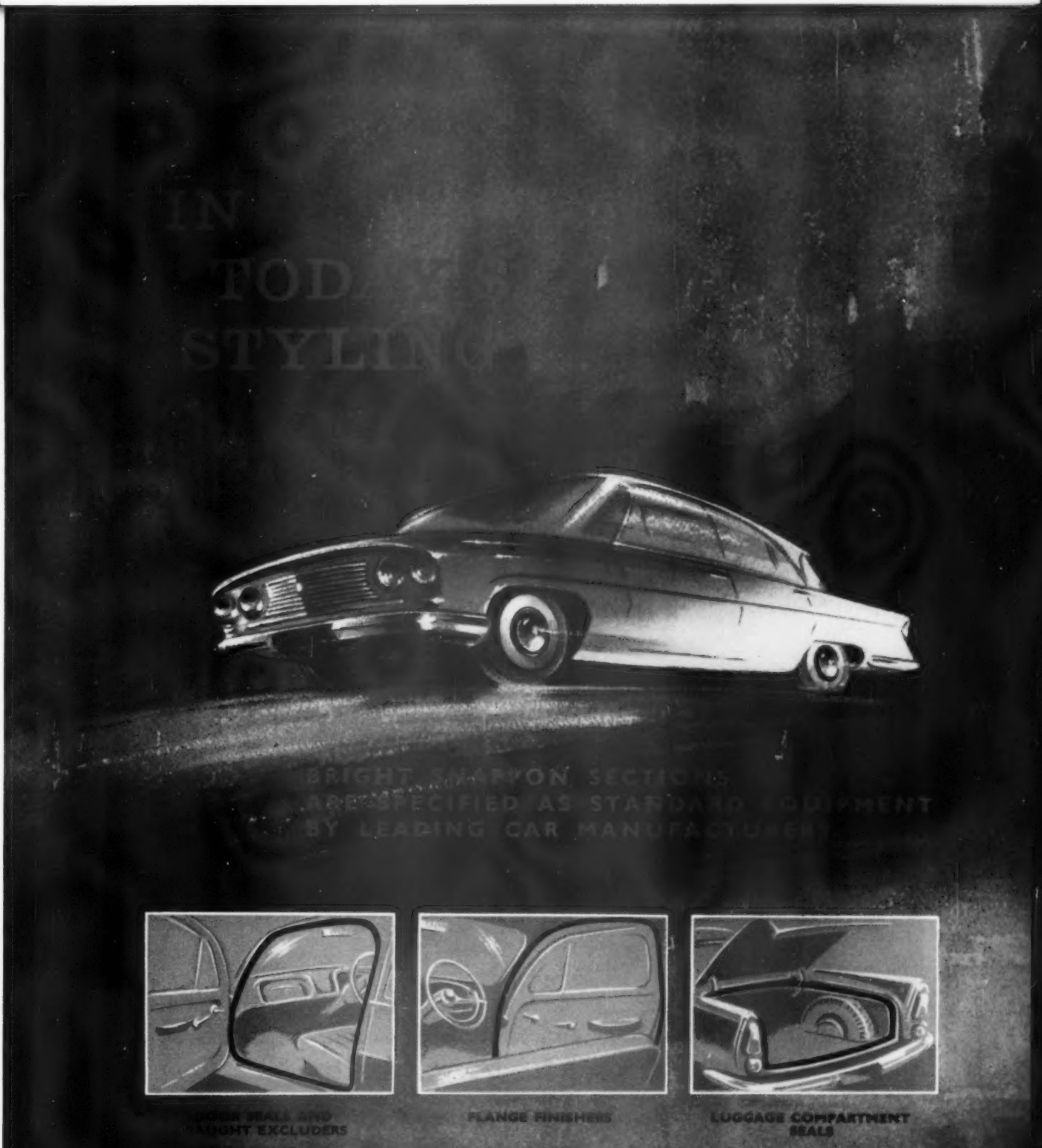

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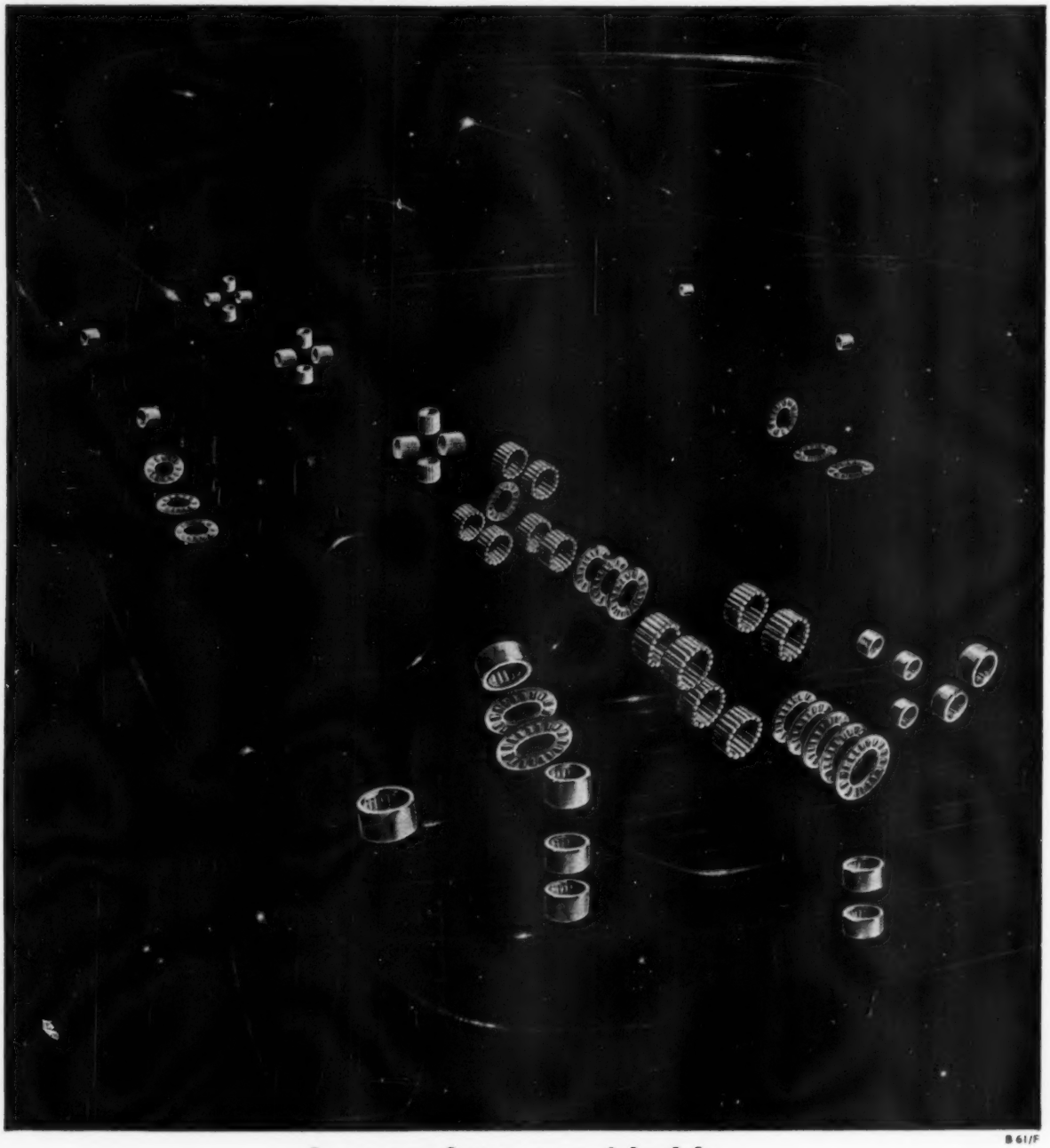

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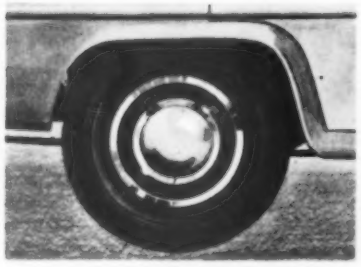

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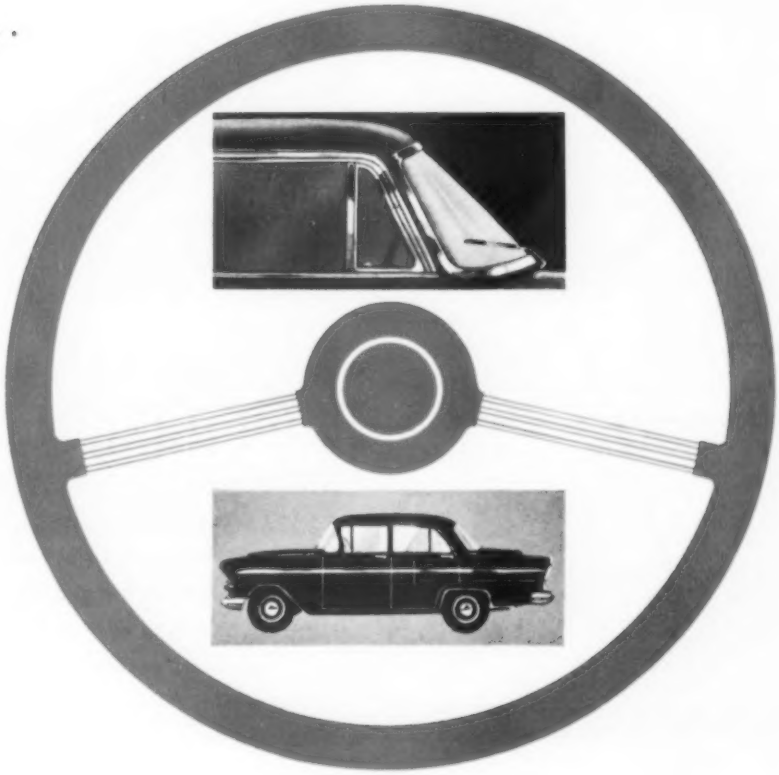

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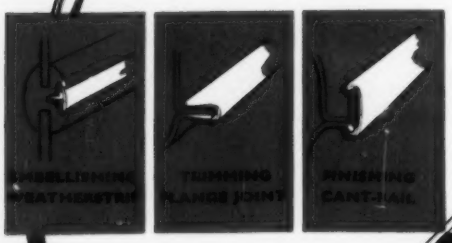

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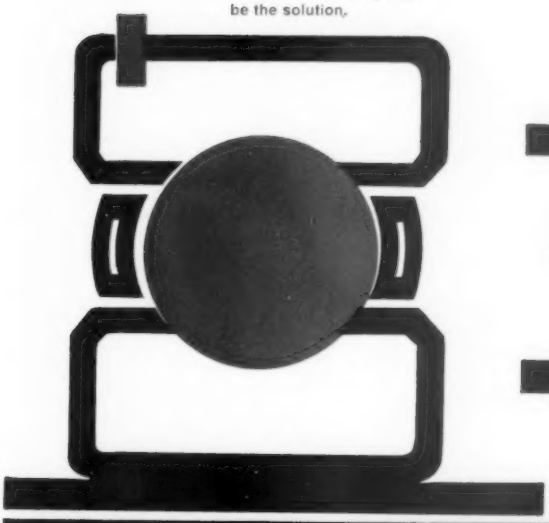
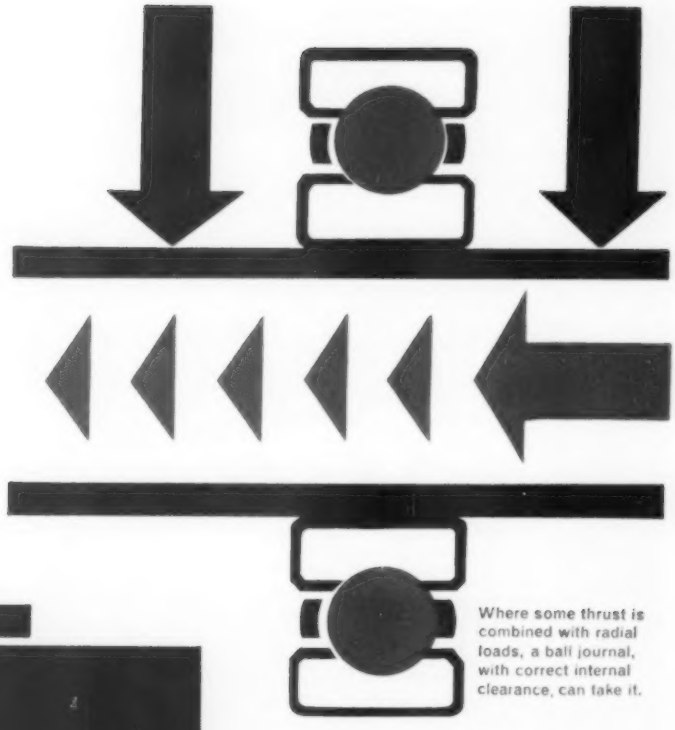


When location difficulties occur, an external circlip fitted to the bearing may be the solution.



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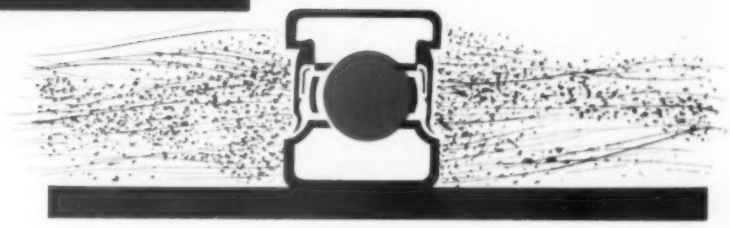

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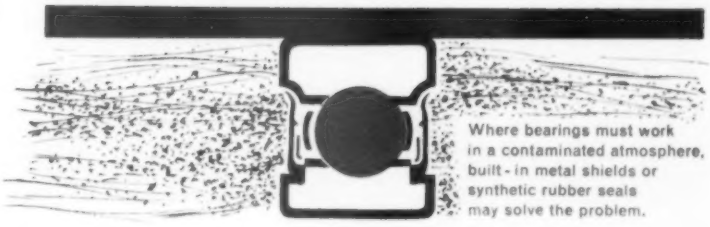
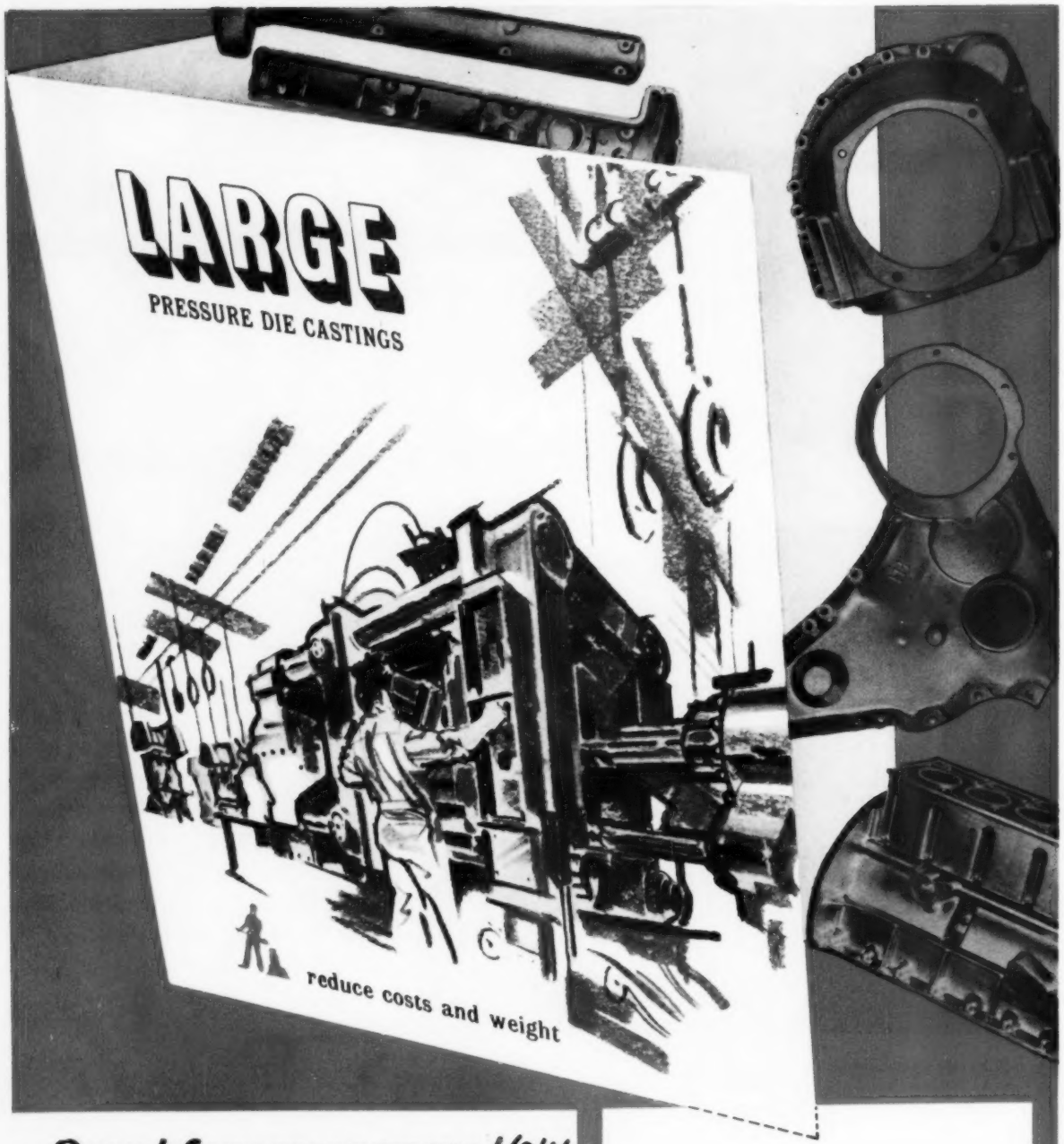


Where bearings must work in a contaminated atmosphere, built-in metal shields or synthetic rubber seals may solve the problem.



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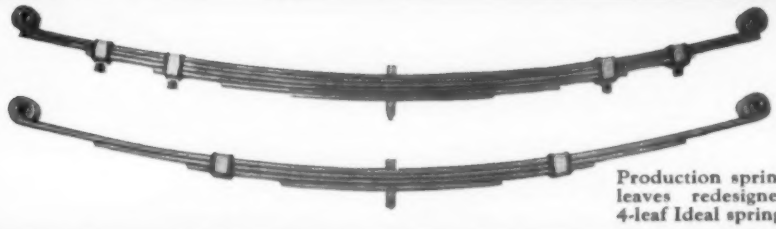
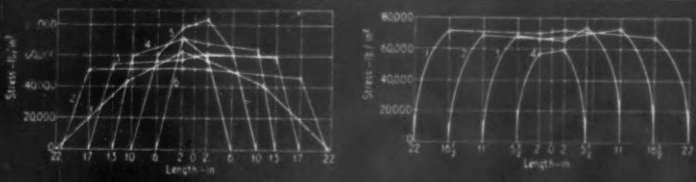
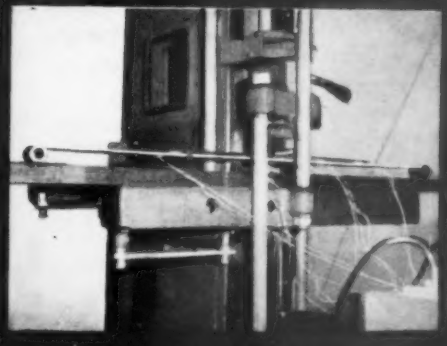


Production spring with 6 leaves redesigned as a 4-leaf Ideal spring.



15-leaf commercial vehicle spring redesigned as 12-leaf Featherlight equivalent without increase in maximum stress.



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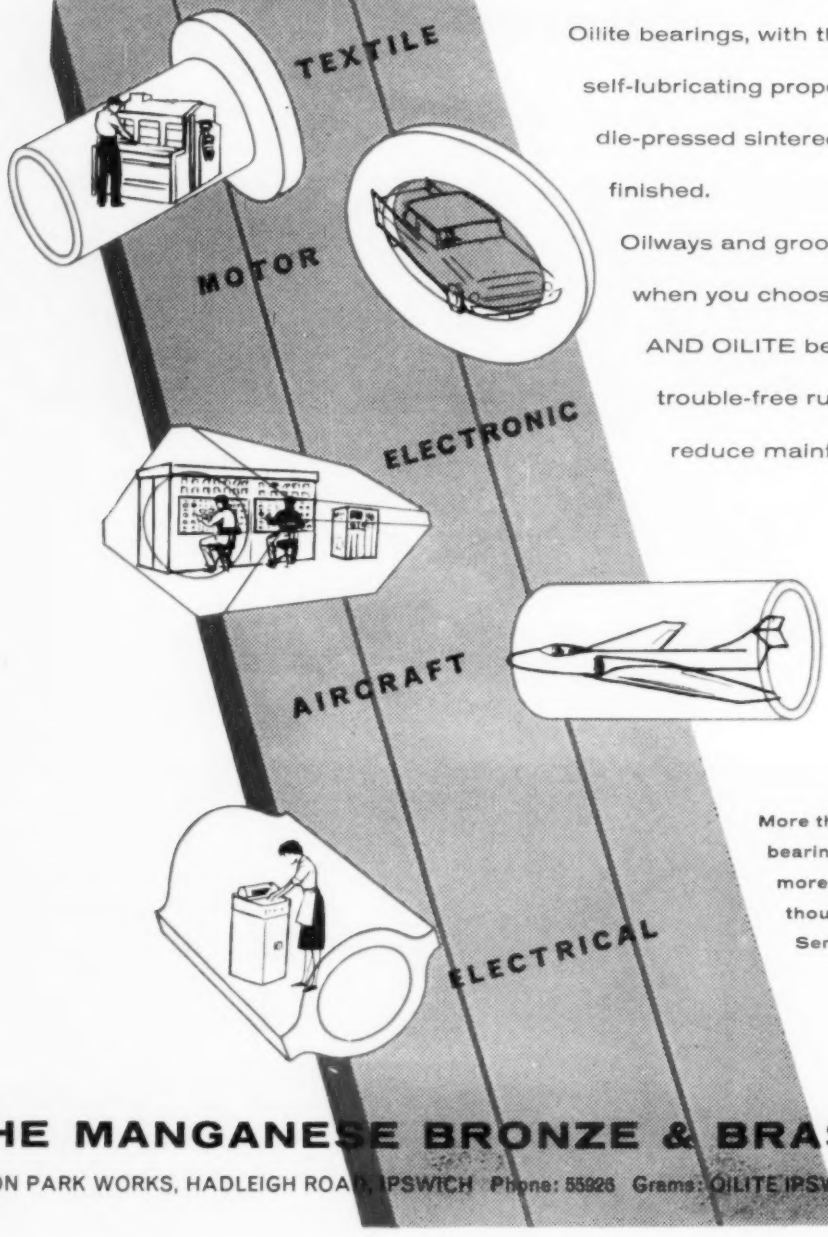

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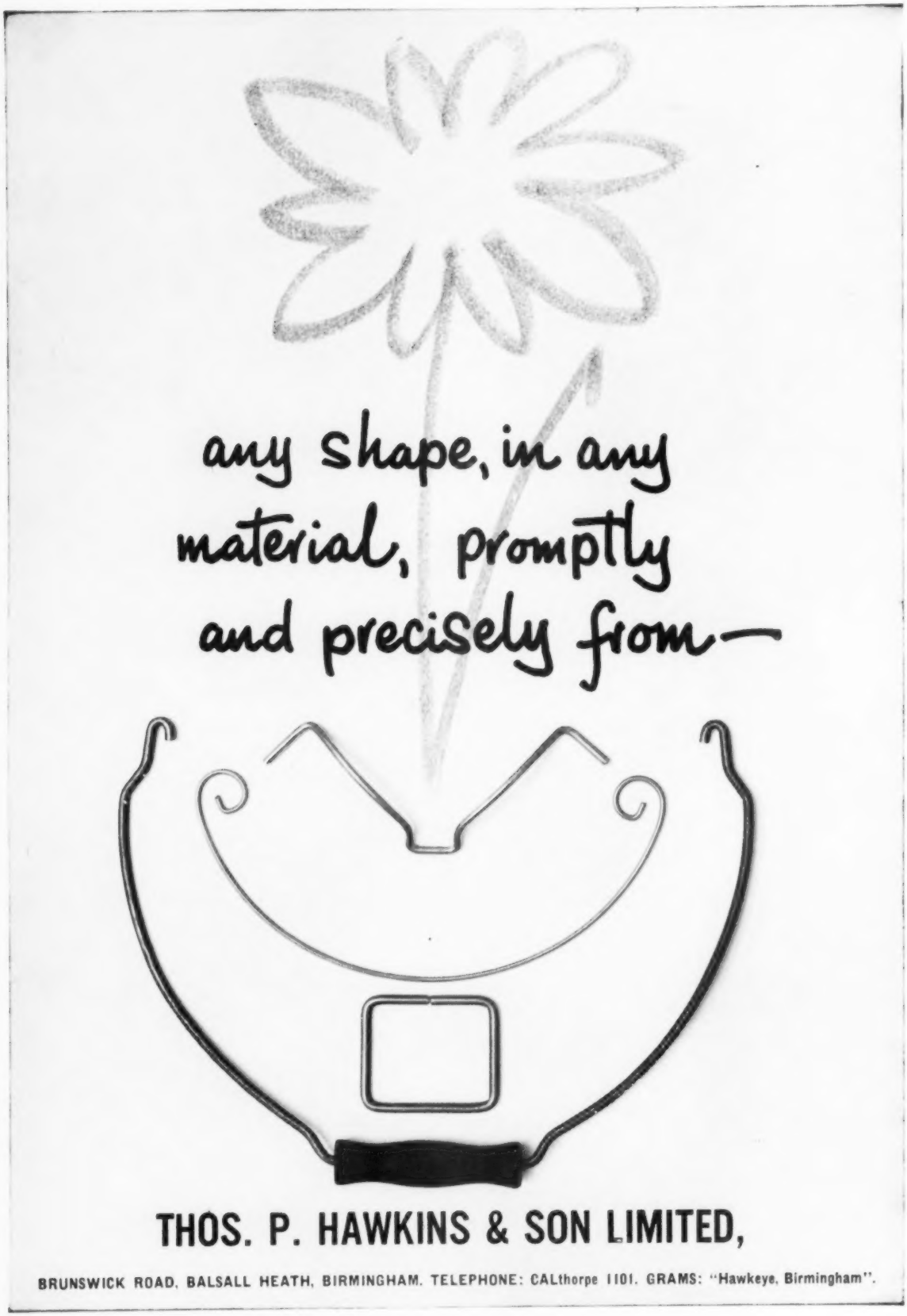
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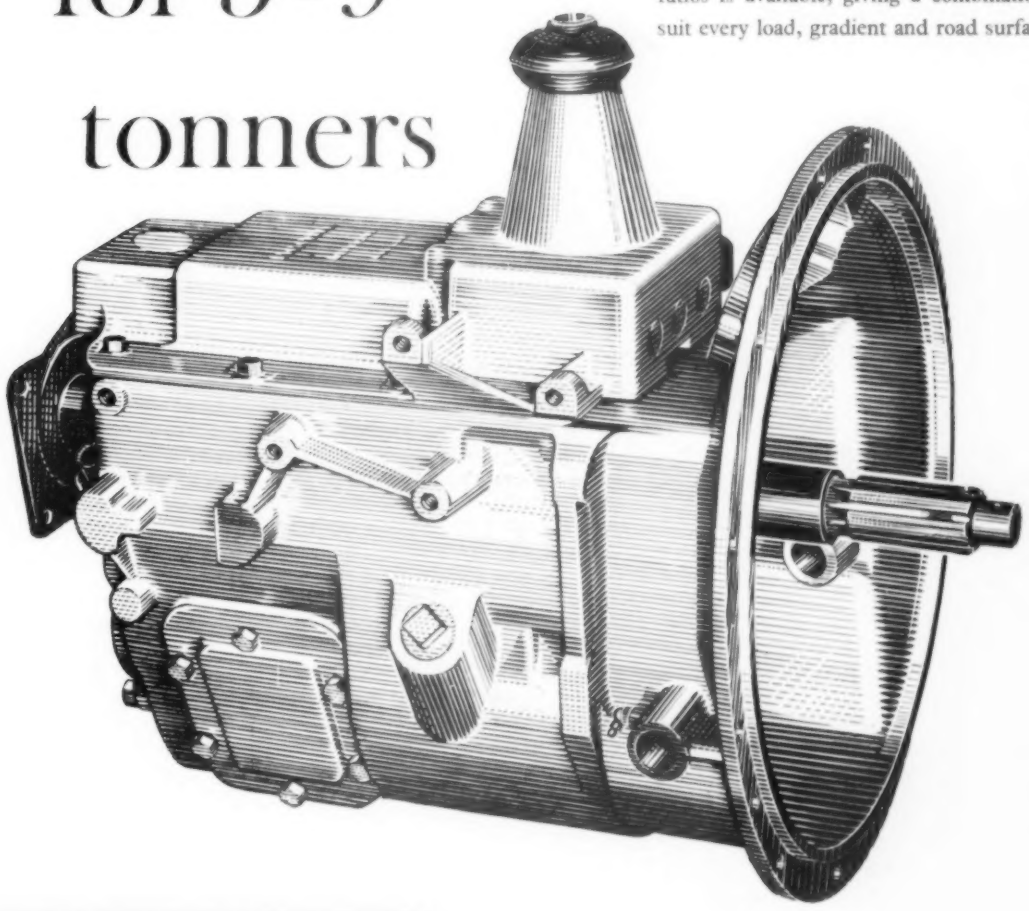

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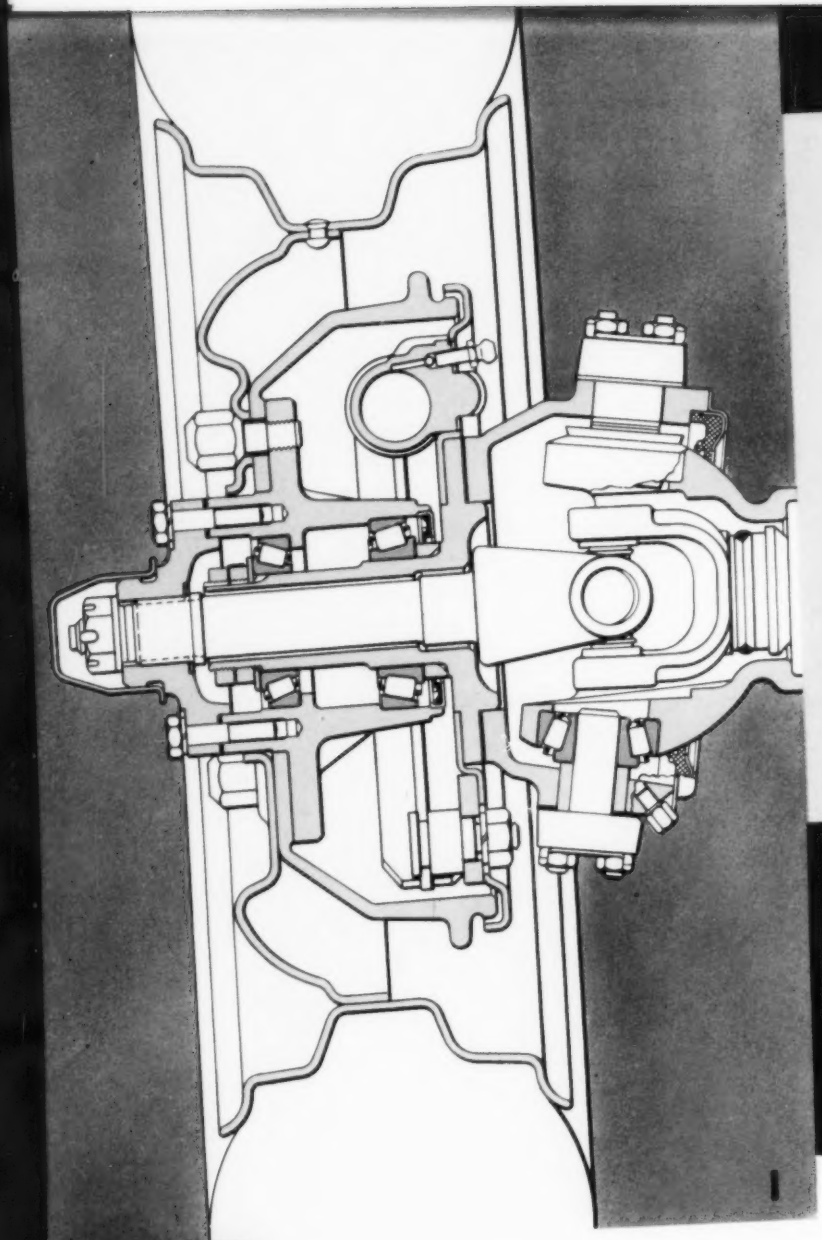

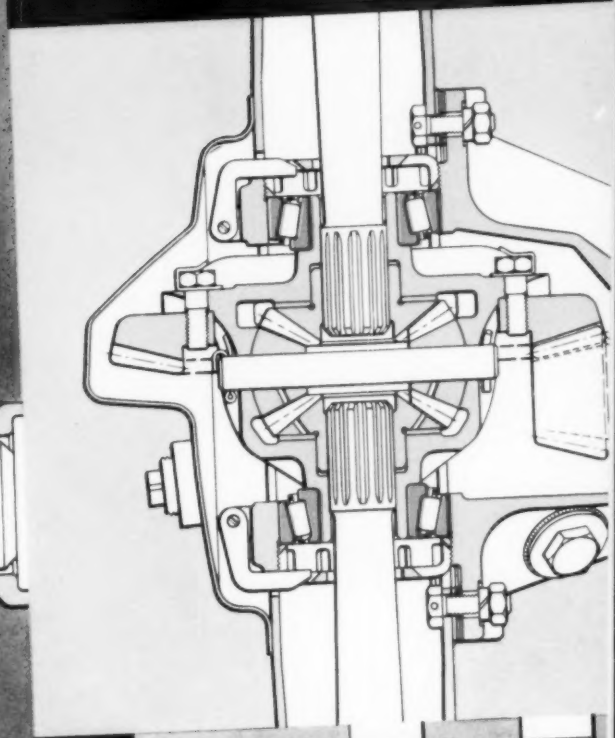

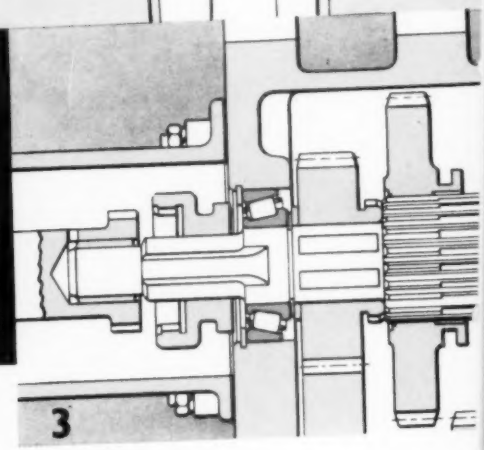

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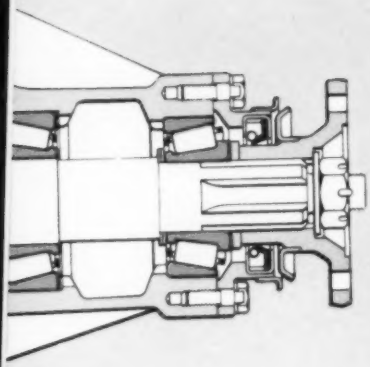

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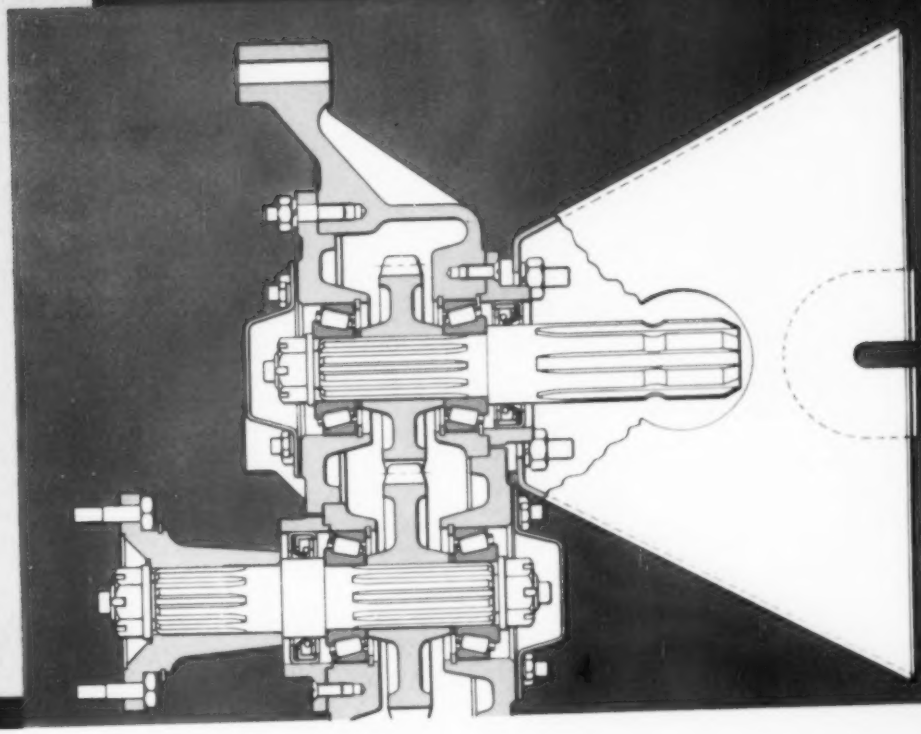

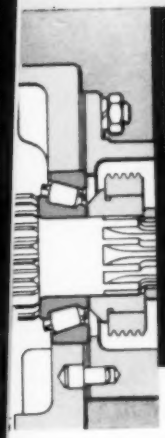

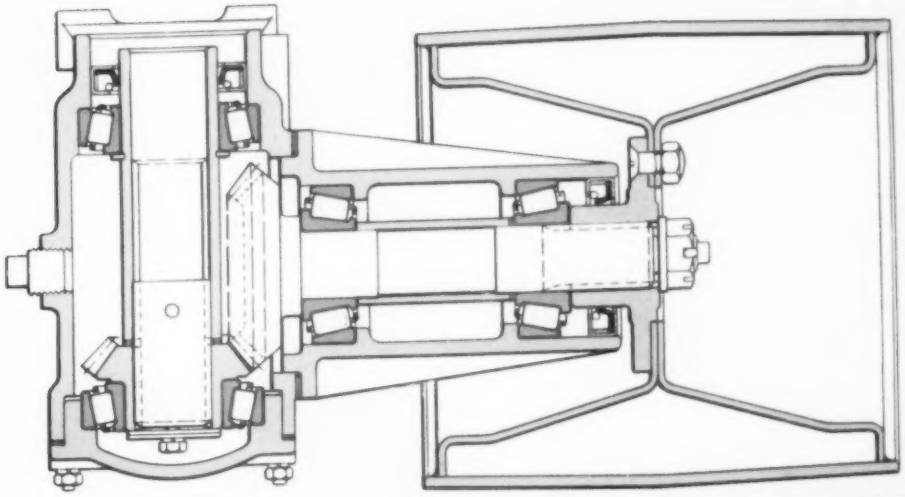

5

1. *Front wheel drive*
2. *Front and rear axle.*
3. *Transfer shaft to front and rear drive (gear box).*
4. *Power take-off unit (drive section).*
5. *Power take-off assembly (pulley section).*

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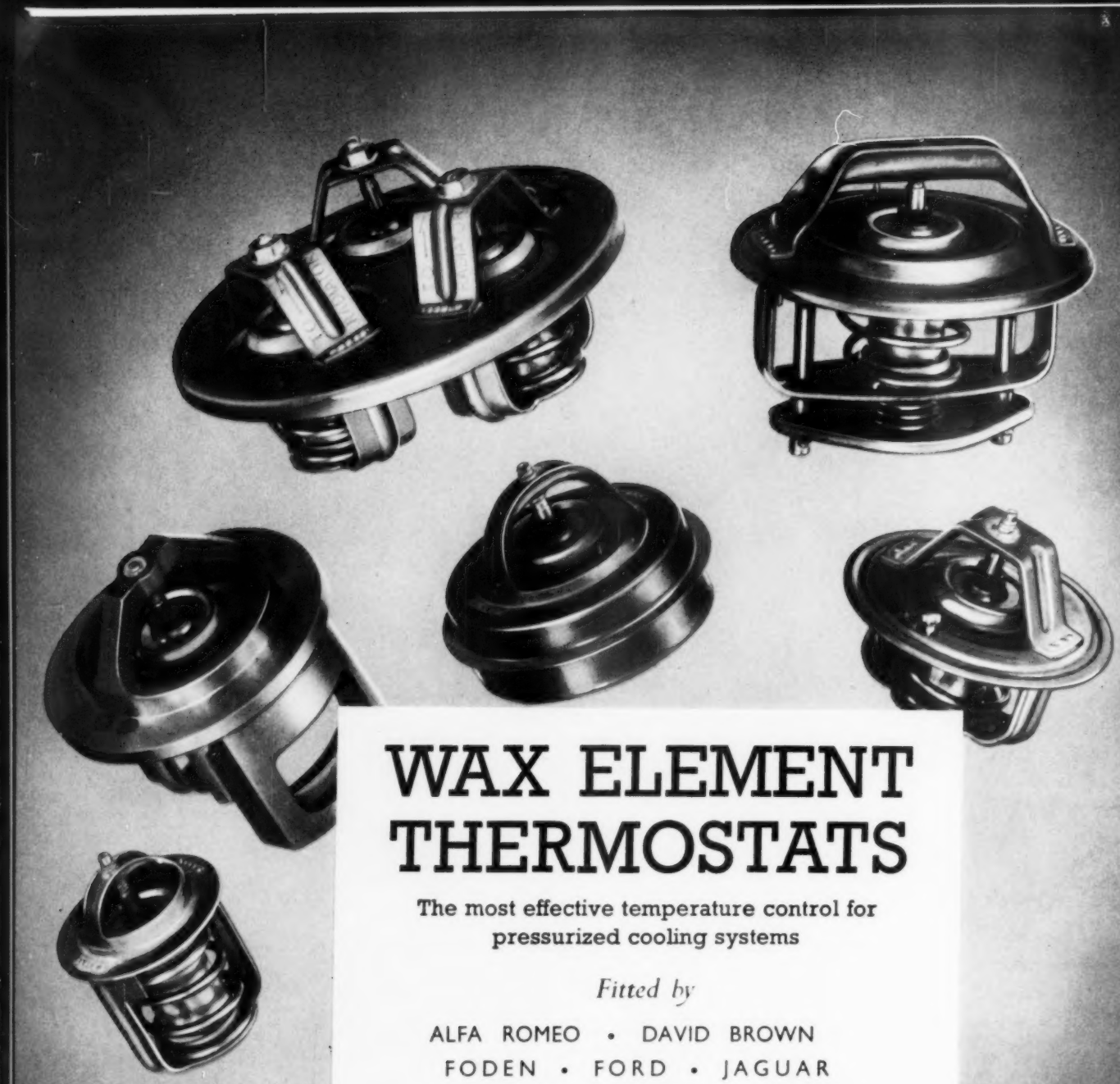

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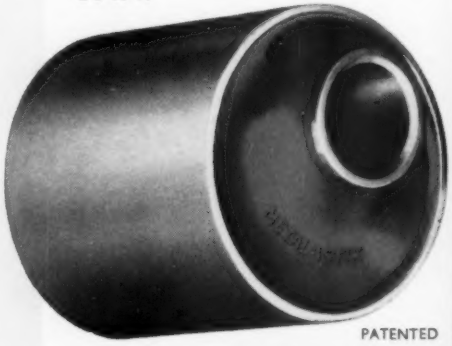

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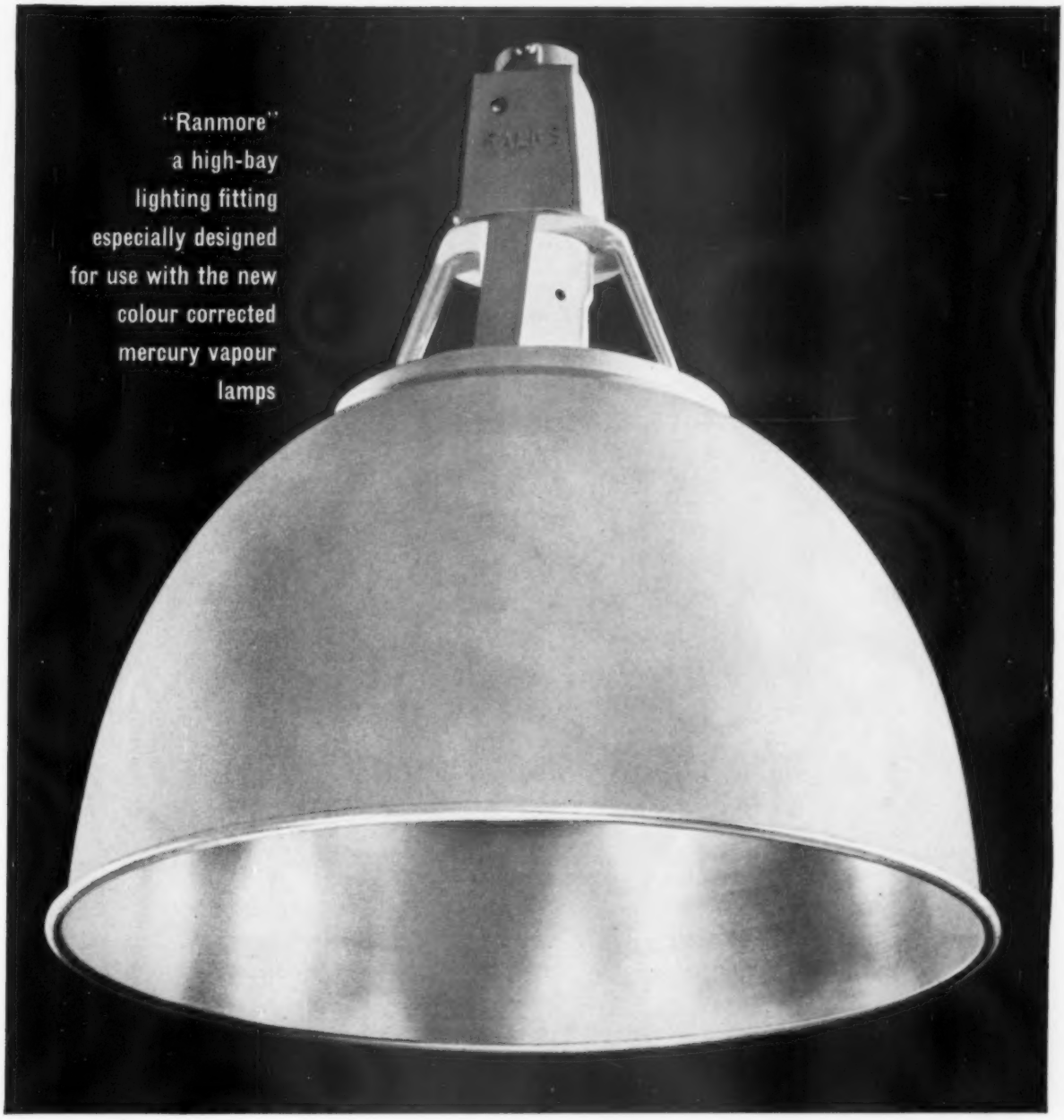

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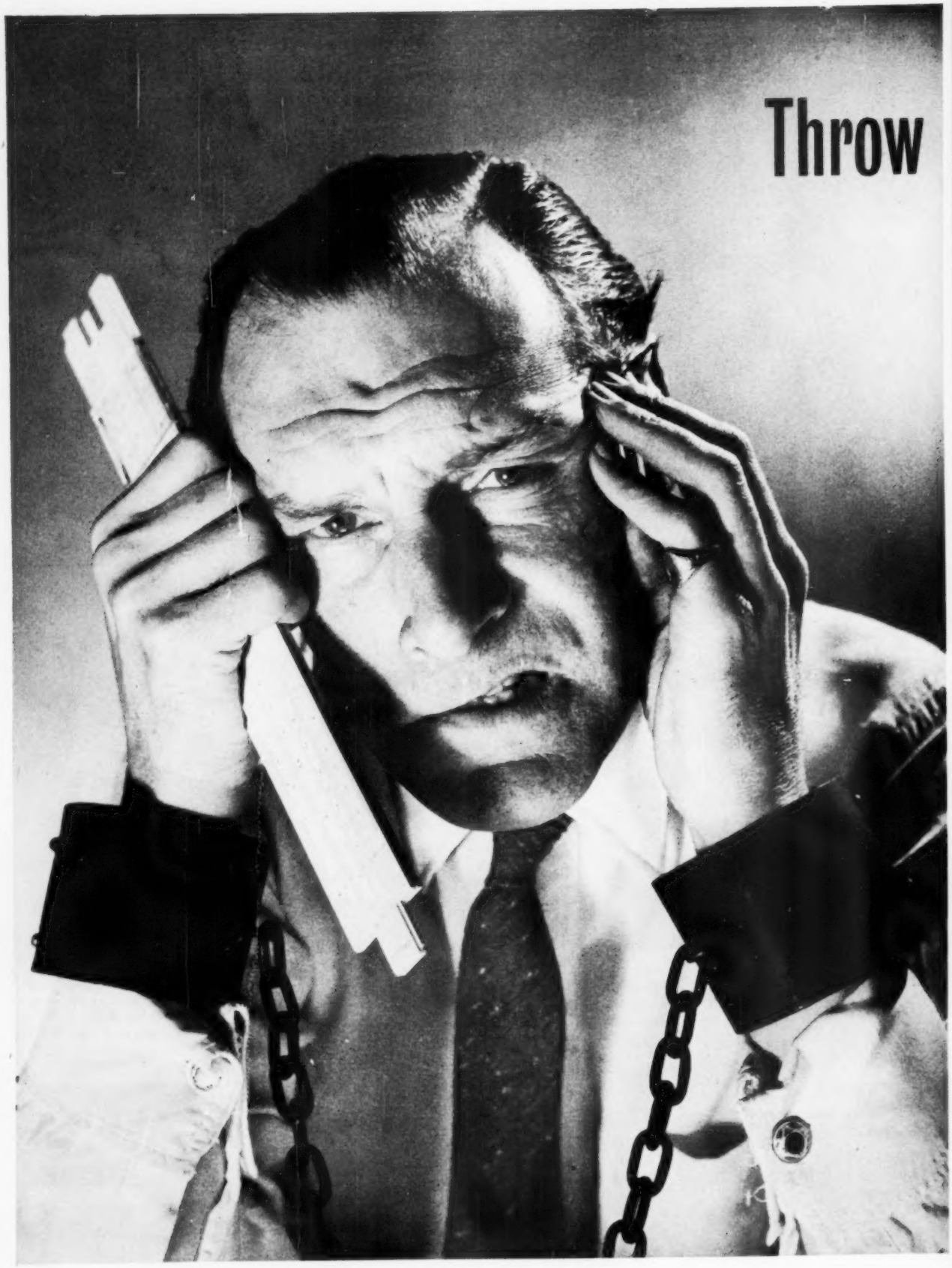
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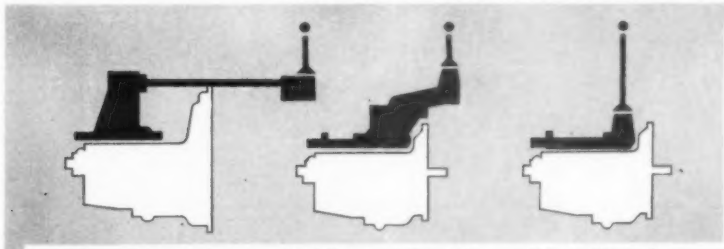

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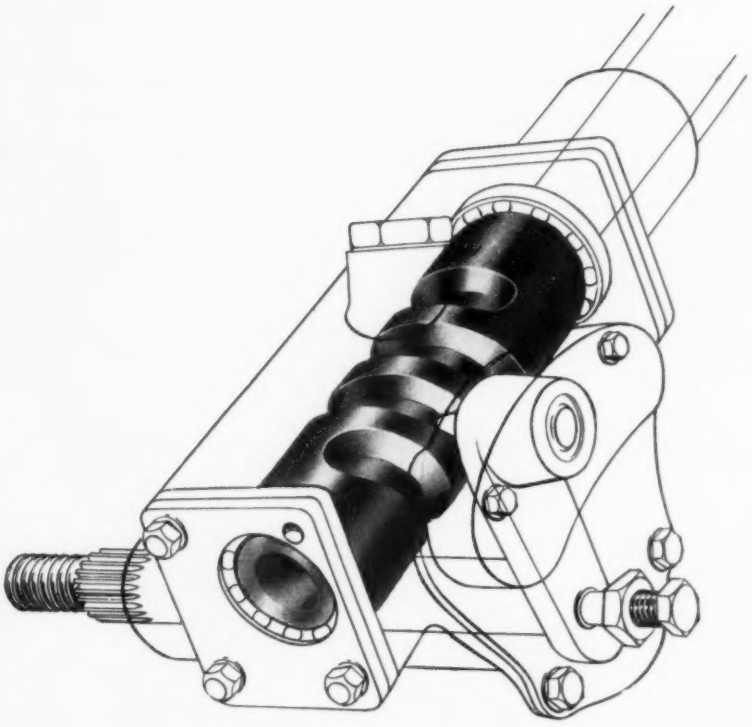

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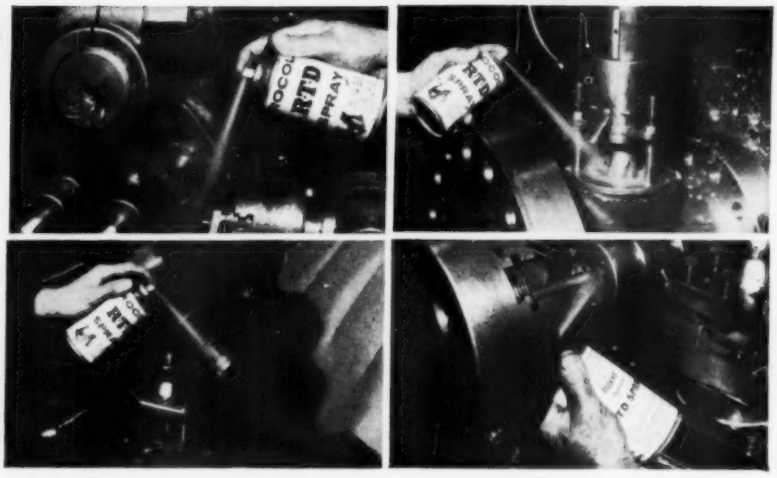

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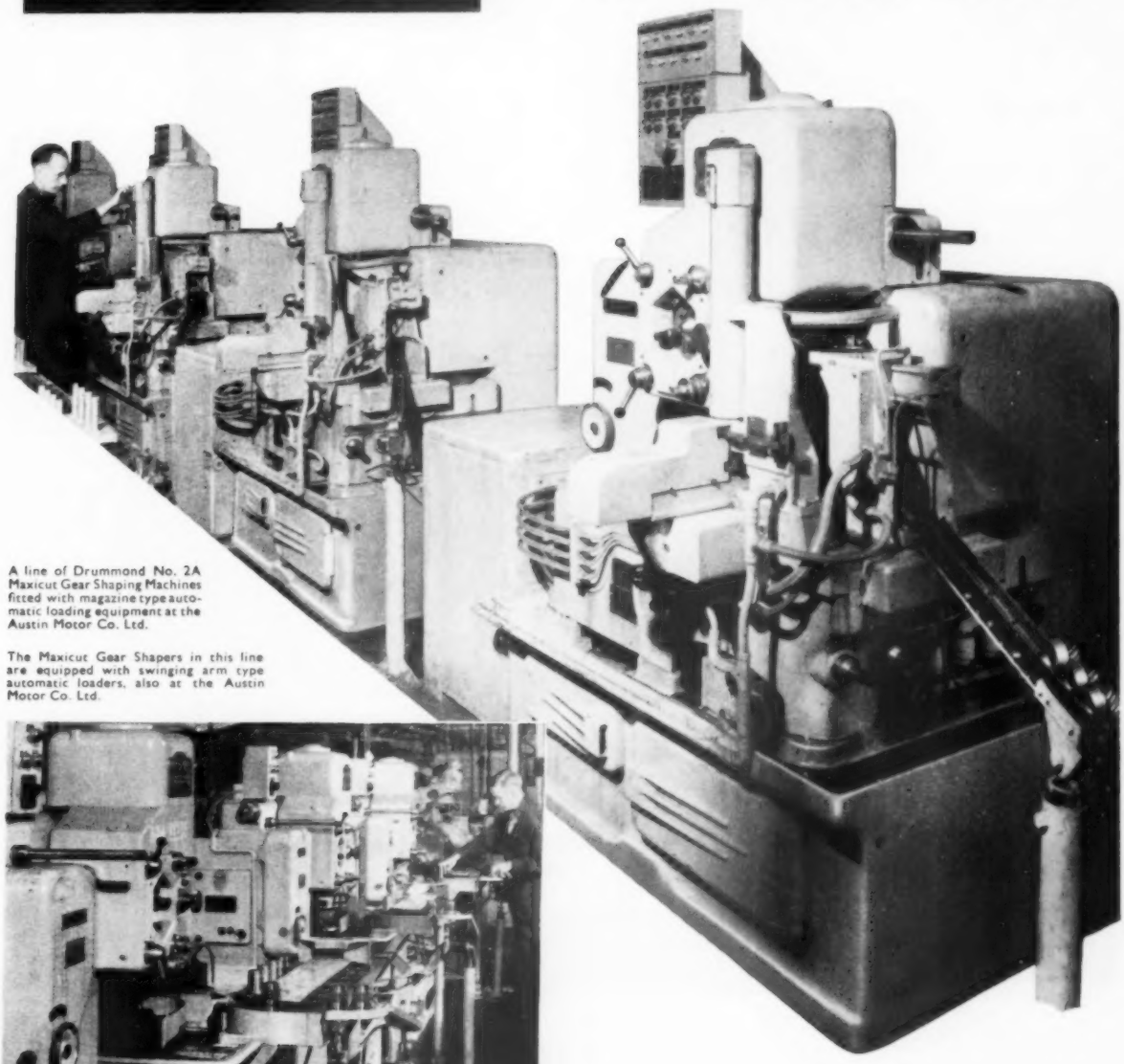

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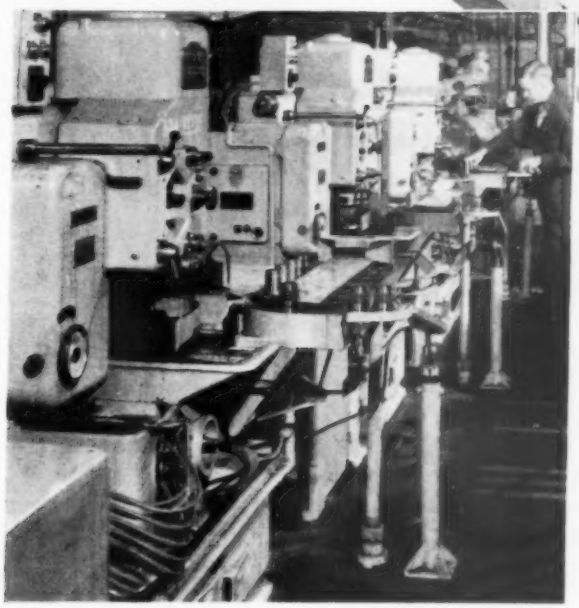

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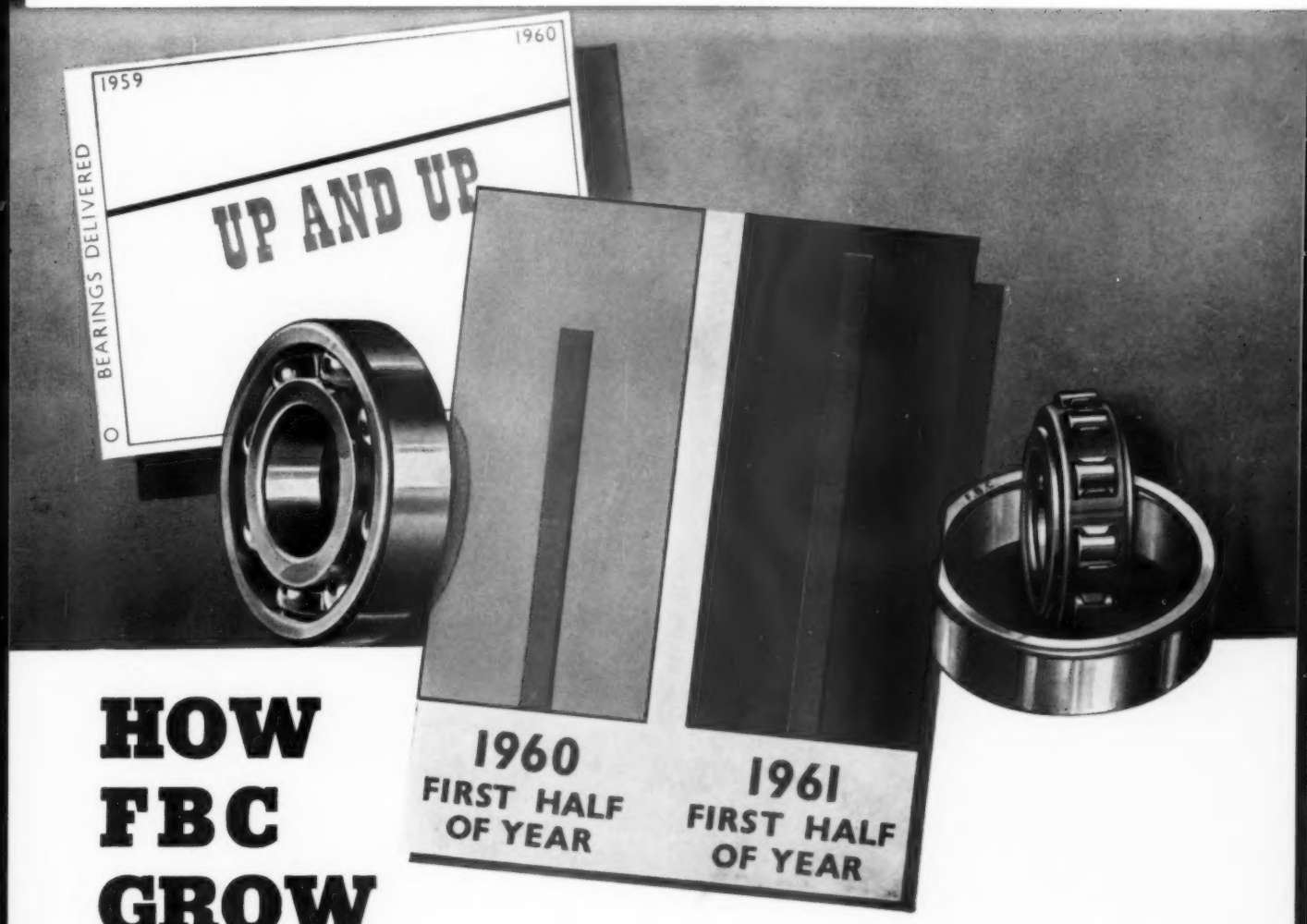

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NOVEMBER 27 1961 Volume 51 Number 12

AUTOMOBILE ENGINEER

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Published the second Wednesday in every month by ILIFFE PRODUCTION PUBLICATIONS LIMITED, Dorset House, Stamford Street, London, S.E.1
Telephone: Waterloo 3333 (65 lines). *Telegrams*: Sliderule London-SE1
The annual subscriptions inland and overseas are: £3 0s 0d including the special number; Canada and U.S.A. $8.50

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AUTOMOBILE ENGINEER

DESIGN · MATERIALS · PRODUCTION METHODS · WORKS METHODS

Pointers for the Future

THE London Show this year has, perhaps, provided more pointers for the future than has any preceding exhibition of its kind since the 1939-45 war. The greatest advances have been in respect of engines, transmissions and brakes, but there have also been significant detail improvements in almost every other field.

Engine compression ratios have, in many instances, been forced up, in part by public demand, to levels that can barely be justified at the present stage of development. This, together with the upward trend of performance, will impel designers to take further measures for strengthening their engines and maintaining an acceptable length of life between overhauls. Among the features that will have to be considered are the aluminium coating of exhaust valves or the employment of better steels for them. There will also be demands for stiffer crankshafts and stronger bearing materials and, in the case of four-cylinder engines, for five main journal bearings. These demands will be reinforced by the recent introduction of high performance versions of standard engines. It will also be worth while to pay more attention to ignition automatic advance characteristics in respect of both accuracy and varying the settings to cater for different grades of fuel.

So far as aluminium cylinder heads are concerned, accuracy of form and location of the ports is obtained by gravity diecasting in metal moulds, with shell-moulded sand cores. Although the majority of aluminium cylinder block and crankcase units are sand castings, pressure diecastings undoubtedly will be used in subsequent models.

Among the new transmission developments is the introduction of diaphragm type clutches, which of course are particularly suitable for high-speed operation. On a quantity-production basis, however, the accurate control of the spring rate will present some problems.

So far, Great Britain leads in the field of automatic transmissions for small cars, and an interesting new electrically actuated transmission has now been announced. Although there have been rumours of interest in hydrostatic transmissions, fundamental considerations, as explained in detail in the ensuing pages, appear to prohibit the use of this type of transmission for cars. Now that further improvements in suspension are reducing noise and vibration levels in cars, rolling element spline couplings will have to be considered seriously for incorporation in vehicle transmission drive lines.

One new rear-wheel drive car with independent rear suspension has been introduced, and another has the de Dion system. The former cannot fail to influence design trends. It is, of course, the belief of many that independent suspension on all wheels is certain eventually to become the rule. A most interesting development is the employment of a single leaf in each rear spring of an American vehicle. The advantage of employing this type of spring is, of course, that the unpredictable friction between the leaves is obviated. It is perhaps not always realized that, because of interleaf friction, there is almost invariably a very high rate characteristic over small, high-speed deflections from the static condition: in fact, within limits, this rate can be much more than ten times the mean rate.

One of the outstanding features of this year's Show has been the introduction of disc brakes as either standard or optional equipment on the majority of British cars. In most instances, so far as family saloon types are concerned, these brakes are installed only on the front wheels. Emphasis is now on safety and, in this connection, divided line systems—in which the hydraulic circuits for the application of the front and rear brakes are entirely independent—are bound to become increasingly popular and, indeed, are likely to become a legal requirement. Power assistance, hitherto regarded as a luxury, will undoubtedly be more widely adopted, especially with disc brakes. These servo systems not only reduce the strain of driving, but also increase safety, because they make full braking power immediately available without undue effort on the part of the driver. Pressure limiting valves, to prevent the locking of rear wheels when the brakes are applied, are another safety feature that is being viewed with increasing favour by the motor vehicle manufacturers.

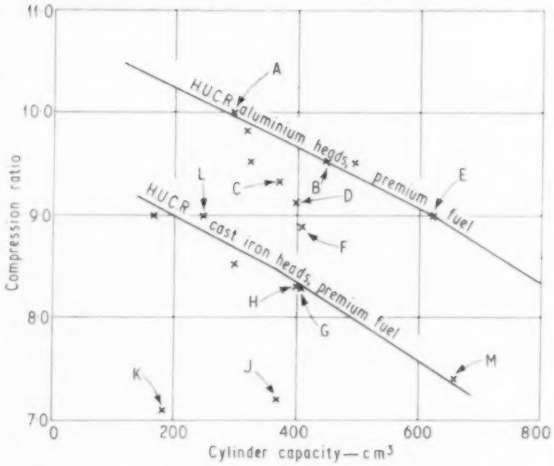
LONDON SHOW REVIEW

ENGINES

Compression Ratios Still Increasing; Renewed Interest in Crankcase Ventilation, and More Engines Are Now Fitted With Aluminium Alloy Cylinder Head Castings

AT last year's Earls Court Exhibition, it was very apparent that the advent of the American compact car was going to have a profound influence in world markets. At the same time, the student of design could not help being aware of the high engine ratings that some of our Continental competitors were using. This double challenge has obviously been recognized by our manufacturers, and considerable advances have been made in the past year. These advances are obvious when a table of comparative brake horsepower and torque figures is studied, but in most cases they are of a relatively subtle nature. Although outputs have been raised by the adoption of higher compression ratios, modified cam forms, improved porting, larger valves and so on, considerable additional improvement is, in many instances, the result of providing better lubrication systems, increased bearing areas and stiffer crankshafts.

In this review, it is proposed to devote more attention to the changes made by manufacturers than to descriptions of the engines themselves. Where a new engine is concerned, however, the design features will be described more fully. The accompanying graph, which resembles that reproduced last year, shows compression ratio plotted against cylinder capacity for engines that have iron or aluminium cylinder heads. It is noteworthy that the point for the B.M.C.-Cooper ADO 50 engine, which has 275 cm³ per cylinder and a compression ratio of 9 : 1, lies above the plotted line for units with iron heads and running on premium fuel: in fact, the manufacturers recommend the use of 100-octane fuel.



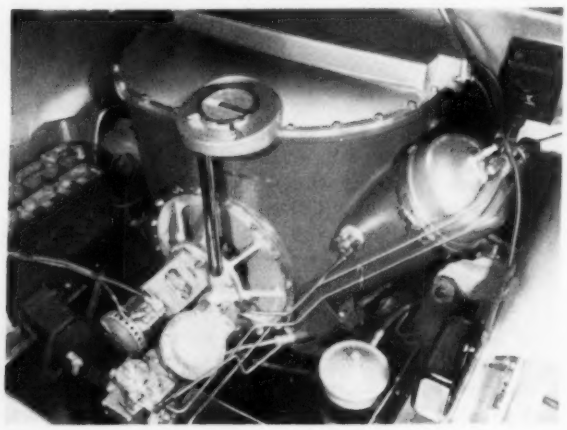
With aluminium heads: **A** *Coventry Climax 1,220 cm³ FWE;* **B** *Volvo P1800;* **C** *Vauxhall VX 4/90;* **D** *Sunbeam Alpine Mk II;* **E** *Jaguar Mk X. With iron heads:* **F** *MGA (requires 100 octane);* **G** *MG Magnette;* **H** *Hillman Minx;* **L** *B.M.C.-Cooper ADO 50 (requires 100 octane);* **M** *Jensen. Air-cooled, with aluminium heads:* **J** *Volkswagen 1500;* **K** *DAF*

Highest useful compression ratios plotted against cylinder capacity

The compression ratios of many other engines have moved nearer those represented by the lines shown on the graph, and the plot of the new Vauxhall VX 4/90 unit is interesting in that it exemplifies the latest thought on permissible compression ratios. Other engines plotted are the tuned version of the Triumph Herald 1200 and the Volkswagen VW1500. Thus, the trend of change can be seen, and the line of demarcation between compression ratios permissible with premium and 100-octane fuels begins to become apparent. This demarcation is still not completely clear, however, probably because the permissible compression ratio for premium fuel has not yet been reached by some of our manufacturers and, as yet, there are no British engines that have been designed to make the most of the highest-grade fuel.

On the subject of compression ratios, one large manufacturer of cars now provides distributors with modified advance characteristics to suit world areas where the fuel quality is low; by this means, lowering of the compression ratio is avoided, with consequent production economies. It could be that an engine with a very high compression ratio for a particular fuel, yet fitted with a suitable distributor to avoid detonation on full throttle, would show a better

Chrysler gas turbine installation. Because of the low inertia of gas turbine engines, a combined starter-generator unit can be employed



overall fuel consumption than one with a lower ratio, owing to its considerable advantage in respect of the part-throttle consumption.

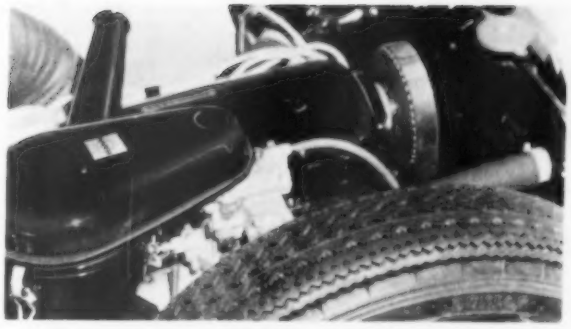
Paper element air filters have improved considerably since the previous London Show. As mentioned in last year's review, their life was limited, especially in the presence of any diesel or lubricating oil fumes. New techniques in the impregnation of the paper have almost overcome this drawback, and the elements now have a much longer life: under normal conditions in the United Kingdom, a life of 30,000 to 40,000 miles can be expected before replacement, without the need for any servicing during that period.

Engine ventilation is one of those subtleties mentioned earlier that has obviously occupied the minds of many engineers, but no common solution is yet apparent. Probably owing to the high standard of the sealing now effected between the engine and the passenger compartment, some manufacturers tend to overlook the importance of the actual position of the discharge of crankcase fumes, despite the fact that the volume of these fumes can be considerable. Since piston ring gaps are nowadays in the region of 0·020 in, and cylinder working pressures of 800 lb/in^2 are normal, it is clear that from this source alone a substantial quantity of acidic gas can be entering the bottom half of the engine. One well known piston manufacturer quotes the blow-by on a ft^3/min basis and asserts that a reasonable figure for a new engine is given by:

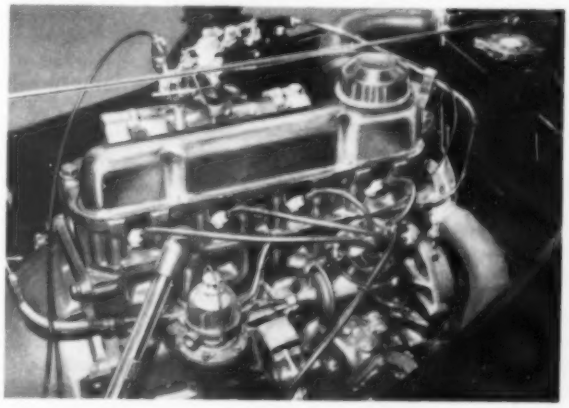
$$\frac{\text{r.p.m. at peak power} \times \text{swept volume, in}^3}{1{,}000{,}000} \text{ ft}^3/\text{min}$$

In the case of a typical 2 litre engine, this formula gives 0·6 ft^3/min.

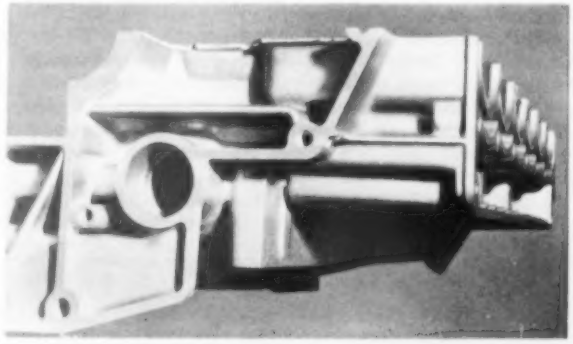
The other source of internal fumes is the clearance between the exhaust valve and its guide, and it seems reasonable that some engine designers prefer to vent the valve gear cover, rather than let the fumes find their way to the crankcase. Sometimes a shield is fitted to prevent air from the cooling fan blowing directly on the front of the rocker box and thus causing internal vapours to condense. The DAF horizontally opposed two-cylinder engine has a rubber non-return valve for crankcase ventilation; the problem in this instance is the



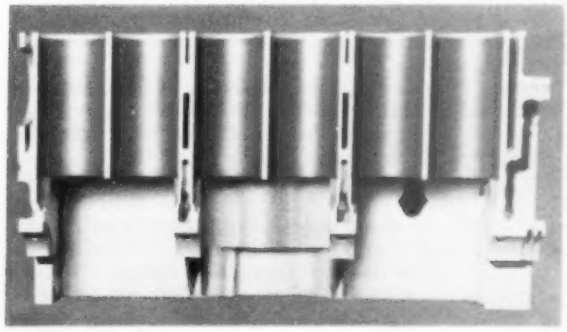
A PowerGrip belt drives the camshaft of the Goggomobil 993 cm³ engine

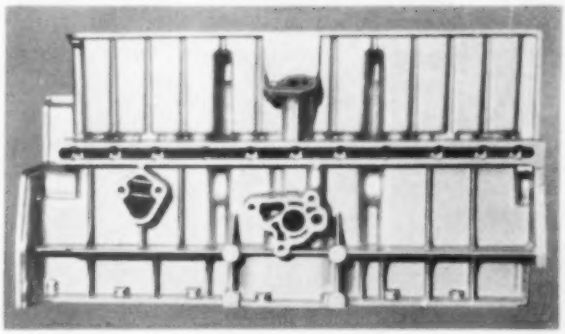


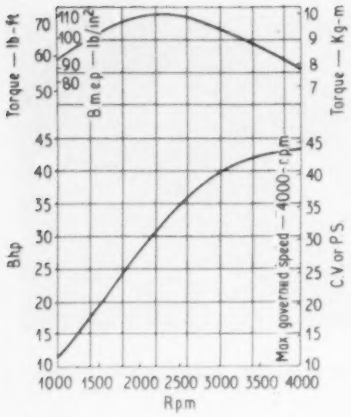
Ford engine installation in the Morgan 4/4 Series IV two-seat tourer



The three views in the group of illustrations below and on the right are of a sectioned diecast aluminium cylinder block of the new Rambler six-cylinder power unit. It has cast-in iron liners and an open top







Power curves of the Perkins 1·6 litre, 4/99 diesel engine, which is offered as a conversion for car installations

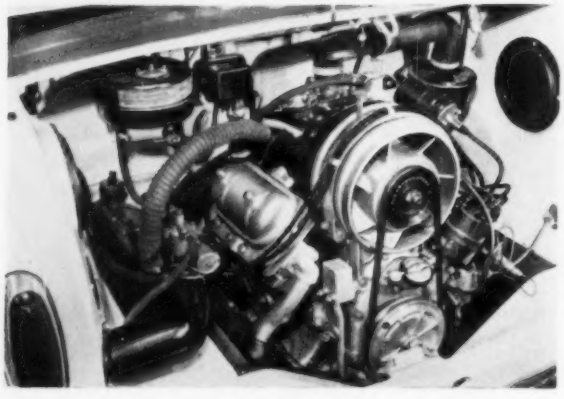
rapidly fluctuating crankcase volume, since the two pistons move in and out simultaneously.

A similarity of thought on the subject of engine ventilation was revealed by the views of two prominent engineers from different companies. They both felt that a reasonable fume consuming arrangement is of a sealed or nearly sealed crankcase, with a coupling pipe to the engine side of the air cleaner. One of them averred, however, that a flame-arresting gauze was necessary to prevent any popping back that might occur from causing minor explosions within the unit. This method of ventilation is normally arranged to provide a small degree of crankcase depression, thus reducing the possibility of oil leaks. It has the disadvantage, though, of allowing dust and foreign matter to be drawn into the engine at any point where air can enter. Consequently, a specific air entry point, with adequate filtration, should apparently be provided, in order that a fresh air stream can help the crankcase vapours to be consumed: oil leaks should be avoided in other ways.

In the State of California there are laws requiring a car to consume its crankcase gases—to reduce contamination of the atmosphere—and with this in mind, some American car companies offer, as an optional extra, special crankcase ventilation systems in place of what they refer to as "road draught" ventilation. One method in use on some large V-eight engines is the fitting of a small-bore pipe, with a suitable restriction, between the induction manifold and an oil-free spot in the crankcase, thus using the manifold depression for crankcase venting at small throttle openings or under over-run conditions. A coupling pipe to the air cleaner is used for the open-throttle condition.

If this system is used on our small engines, there is the difficulty of maintaining a slow idling speed, owing to the extra air entry to the manifold, and there may be problems with regard to starting in very cold conditions. In the many cases where a 1 mm diameter hole is used for providing a hot spot drain, this hole could be fitted with a non-return valve that would only allow drainage of the excess fuel when there was no manifold depression. It would then be possible to take a small pipe connection from the manifold to the crankcase, to provide a fume extractor when the engine is idling. This hole and the pipe to the crankcase would have to be carefully positioned so that at no time could fuel from the manifold reach the crankcase.

Zaporogets 746 cm³, V-four, air cooled, rear engine installation. The oil filler is unfortunately situated directly above the fan drive pulley



The Volga 2½ litre engine features a breather pipe leading from approximately halfway down the woven wire breather element to the rocker gear cover; a second pipe connects the crankcase to the induction tract, between the air cleaner element and the carburettor. In this way, a filtered air inlet is provided, yet the element restriction provides a degree of air circulation. A close study of the accompanying illustrations will, in a number of instances, reveal the breathing systems in use. Two important points to be observed in the design of any breathing system are: avoid any natural traps where condensation can collect and build up sufficiently to prevent air flow, and obviate the risk of any condensate being drawn into the carburettor when the engine is first started. Any inhalation of condensate can increase the tendency to icing-up, or can even cause fouling of the jet assembly.

Seals between valve guides and stems do not appear on any British engine as yet, although it is known that experiments are proceeding with this in view. These seals have the double advantage of reducing exhaust blow-by, and of preventing the entry of oil by way of the inlet valve guides. Teflon p.t.f.e. seals are employed on some American units, and have recently been incorporated on Mercedes-Benz engines. The use in America of a small vent hole to atmosphere half-way down the inlet guide, intended to prevent oil from being sucked down by the induction depression, was apparently not a success, owing to the air leaks upsetting the carburation, and small rubber plugs were issued to the dealers, for blanking these holes.

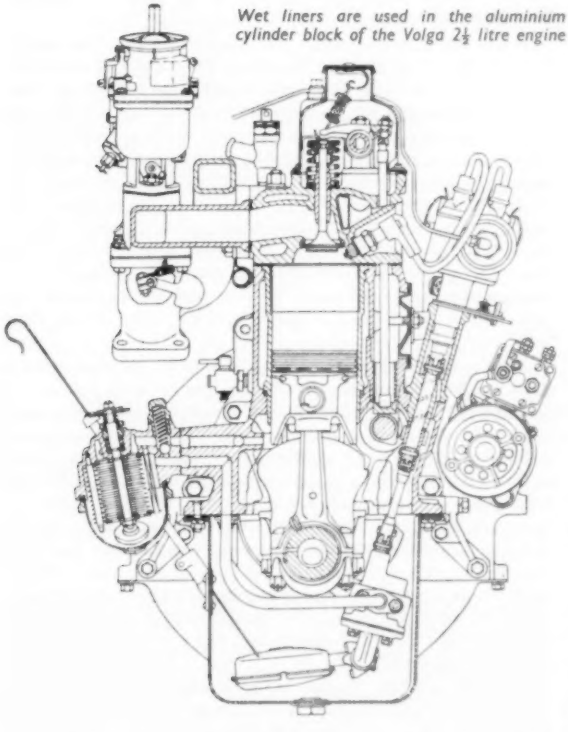
One of the Vauxhall range of engines is now equipped with an aluminium cylinder head. It is that of the high-performance VX 4/90 car, and it has a compression ratio of 9·3 : 1. The combination of this relatively high ratio and other modifications has resulted in a creditable 81 b.h.p. at 5,200 r.p.m. with a swept volume of 1,508 cm³. Although research work both in Britain and abroad is being devoted to producing a fully pressure diecast cylinder head, the most modern method used so far is apparently gravity diecasting of the outside form of the head, using shell moulded sand cores for the water spaces and ports. This method gives great accuracy of port form and good location of the ports in the casting. Where an aluminium cylinder head is mounted on a cast iron cylinder block it is important that the water passages in the two castings are well matched and aligned, to avoid any stagnant pockets of water that can foster electrolytic corrosion. Providing this precaution is taken, modern aluminium heads do not appear to present any corrosion problems.

Interest continues to increase in the use of aluminium as a cylinder block material. Mercedes-Benz exhibited their new six-cylinder 3 litre car, the engine of which has a light alloy cylinder block; the company claimed that this block was 66 lb lighter than the equivalent iron casting. Apart from Coventry Climax Engines Ltd, who have been building both petrol and diesel engines with aluminium cylinder blocks for many years, A.C. Cars Ltd. and Aston Martin Lagonda Ltd. are the only British manufacturers to have an aluminium cylinder block in production. Displayed on the Rambler stand was a six-cylinder diecast aluminium

block, sectioned to show details of the cast-in cylinder liners and the suitability of the general design to diecasting techniques. In cases where a heat treated aluminium alloy is used for cylinder blocks, experience has shown that, after the normal heat treatment, a stress-relief annealing treatment helps to minimize distortion.

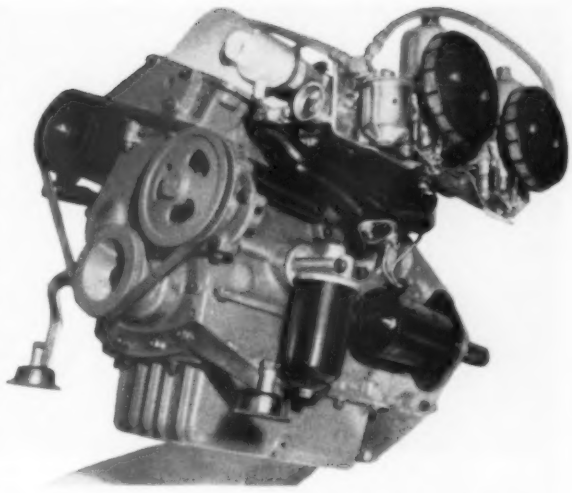
The Volga 2½ litre four-cylinder engine mentioned earlier has an aluminium block; this was a sand casting in the car exhibited, but a fully pressure diecast block is being introduced: this was described in the September issue of *Automobile Engineer*. To summarize the present situation, the following in-line engines feature sand cast blocks: A.C, Aston Martin, Buick, Dodge, Ferrari, Lagonda, Mercedes-Benz 300SE, Skoda and Rolls-Royce; Rambler and Volga are the first to have a diecast block, but several more are known to be under development. Chevrolet, of course, use the British Alumasc low-pressure diecasting process for the blocks and heads of the Corvair air cooled engine.

In the Buick V-eight engine with an aluminium cylinder block, cast iron main bearing caps are employed, to minimize the increase of bearing clearance with temperature: with an all aluminium assembly, this increase can be sufficient to cause what is known as crank rumble. For other reasons, this bi-metallic arrangement has been used in Coventry Climax racing engines, and it is known to have resulted in a noticeable improvement in oil pressure at the very high lubricant temperatures often encountered. On the other hand, Rolls-Royce use an all-alloy assembly in the 6¼ litre V-eight engine.



Wet liners are used in the aluminium cylinder block of the Volga 2½ litre engine

Lubrication and oil filtration systems show minor changes. On the B.M.C. Series B engines there is an inclined, integral pad to carry the filter bowl and element—a modification that was noted in last year's review. Mercedes-Benz have adopted a combined full-flow and by-pass type oil filter: because the main filtration is done by the by-pass portion, the full-flow section is of very meagre proportions. A centrifugal filter, on the nose of the crankshaft, continues to



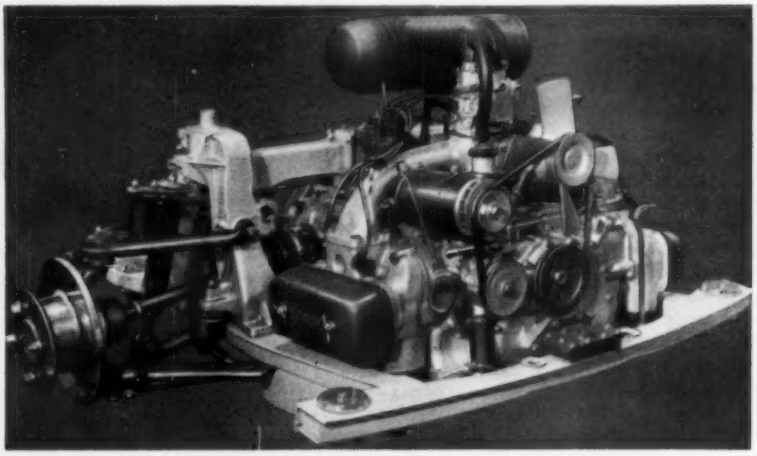
Coventry Climax, 1,220 cm³, FWE engine in this form develops 84 b.h.p.

be employed on several Continental engines. This type of unit is sponsored in Britain by Vandervell Products Ltd. and, although experiments are proceeding, no British manufacturer has yet adopted it for a production car.

It is noteworthy that, on the latest B.M.C. engines, the oil is returned from the relief valve to a point below the oil level in the sump, thus reducing any tendency to frothing and hence improving the performance of the pump. Oil coolers are becoming more common on the higher-performance type of engine: a very neat cooler, manufactured by Morris Radiators Ltd, is a feature of the MGA 1600 car, in which it is mounted in front of the main radiator. An oil cooler is also offered by Rootes, as part of a tuning kit for their Alpine model, and by Aston Martin as an optional extra. Oil coolers are now standard equipment on the Volkswagen and the enlarged DAF engines; in both cases it takes the form of a coiled pipe in the cooling fan duct.

For private cars, diesel engines do not appear to have gained in popularity in this country, although they are in great demand for taxi use, particularly in London. The Mercedes-Benz diesel, now increased from 1·9 to 2 litres swept volume, is a well-developed unit, which endows a large car with a good performance at 30 or more m.p.g. Such is the demand for it that it is said to be installed in approximately 75 per cent of the entire Mercedes-Benz output of four-cylinder cars: many of these are, of course, used for taxi purposes throughout the world. F. Perkins Ltd. continue to market diesel conversions for private cars such as the Ford Consul, Standard Vanguard, Hillman Minx, Vauxhall Velox and Morris Oxford, the 320 lb weight of their 1·6 litre four-cylinder engine being in line with current petrol engine practice. Peugeot appear to be taking greater interest in the diesel market, as also is the B.M.C. group, which has introduced a new 1·5 litre unit since the Show closed. This new unit is derived from the B Series petrol engines, which have the same crankcase and cylinder block.

In recent months, attention has been focused on the desirability of reducing maintenance routines to a minimum. Perhaps one of the most loudly heralded advances has been the Renault Company's sealed-for-life cooling system requiring no maintenance. This system is described later in this section. Another improvement with the same objective is the provision of an automatic belt tensioning device on the dynamo drive. Jaguar Cars Ltd. feature this on the engine of the Mark X car, as also do Renault on the first belt of the two-stage drive to the dynamo of the R4L model; on the last-mentioned vehicle, incidentally, the dynamo is driven



Although at first sight the Lancia Flavia engine design appears to be complex, a closer study shows that it has a remarkably simple layout, despite its horizontally opposed four cylinder arrangement

at such a speed that it charges even when the engine is idling. Recent experience has shown that it is very difficult to detect the onset of belt slip: an engine will operate satisfactorily for weeks when driven in town conditions, but as soon as continuous high-speed running is necessary, the belt drive gives trouble. A very good means of warning the driver that belt slip is taking place has been found to be a tachometer driven from the rear of the dynamo.

The use of aluminium cylinder heads, with their good cooling, and of valve seat inserts of close-grained iron must reduce valve seat deterioration and consequent attention, and the increasing use of overhead camshafts and direct-operating valve gear should further extend the servicing periods. Mileages between changes of oil and filter elements are lengthened by the combination of a centrifugal oil filter and a full-flow or by-pass type filter, while the use of detergent oils helps to maintain the efficient operation of piston rings and valves. Another new item seen on some engines is the self-locking screw for the adjustment of valve clearances. The Chrysler Corporation exhibited a distributor with a tubular contact-breaker point; this was described as a ventilated point and its purpose is presumably to obviate the peak often seen on worn contact-breaker points of orthodox type.

Parallel with the general development trend towards higher engine outputs, British manufacturers have in several cases decided to offer alternative tuning kits, to enable an enthusiastic driver to have a car of considerably higher performance than standard. This has been the practice in the U.S.A. for some time now; since these options are in the official specification, owners can modify their cars for racing, yet still remain in the "stock car" class. The British Motor Corporation has entered this field with the ADO 50 Austin Seven-Cooper and Morris Mini-Cooper, and Triumph offers tuning kits for its Herald 1200 model, as also does the Rootes group for the Sunbeam Alpine. In effect, Vauxhall Motors Ltd. have adopted a similar policy by producing the VX 4/90 high-performance model, the engine of which, by virtue of its aluminium cylinder head, presents great possibilities for further tuning. Ford offer a tuning kit for their Anglia engine, and the A.C. Ace car is now available with the Ford Zephyr engine in various states of tune.

Work is known to be continuing on several gas turbine installations in cars. The Rover Co. Ltd. has recently released some information on its latest experimental car with a 140 b.h.p. turbine, and one of the highlights of the Earls Court Show was the Chrysler vehicle fitted with a resplendent gas turbine unit, stated to develop 140 b.h.p. at 39,000 r.p.m. and weighing only 450 lb. On this unit, a throttle response approaching normal engine practice is claimed to have been achieved.

New engines

Goggomobil seem to be able to produce a new engine design almost yearly. From the twin-cylinder two-stroke unit of 293 cm³, they have progressed to a 392 cm³ version, a horizontally opposed four-stroke twin-cylinder of 688 cm³, also air cooled, and now to a 1 litre four-cylinder water cooled four-stroke unit having a single overhead camshaft driven by an externally mounted, internally toothed belt of approximately 1 in width. This is a PowerGrip drive, and it has no tensioning adjustment. Although the claim is made that no stretch occurs, it would be surprising if the rate of wear were comparable with that of a chain drive, on which a tensioning device has become normal practice to cope with wear that is usually less than 1 per cent of the chain length.

This engine is one of several new four-cylinder units to have a five-bearing crankshaft, which in this instance is unusual in having double counterweights for each crankpin. The stroke is 61 mm and the bore 72 mm, giving a swept volume of 993 cm³. At 4,950 r.p.m, the net output is claimed to be 42 b.h.p, and the compression ratio is 8·5 : 1. The light alloy head has opposed ports, and the inclined valves are actuated by a centrally mounted camshaft and rockers. Another interesting feature is that the water heated induction manifold forms the main coolant outlet from the cylinder head, even to the extent of having the thermostat in the front end, with a by-pass pipe to the forward mounted water pump. The manifold carries a Solex single-choke down-draught carburettor.

Volkswagen now have in production their 1,493 cm³ engine. This follows very closely the lines of the original 1,192 cm³ engine, in being a horizontally opposed, air cooled four-cylinder unit. The bore is 83 mm, and the stroke of 69 mm gives a piston speed of only 1,720 ft/min at 3,800 r.p.m. There have been installational changes to reduce the height to 16 in and thus give more luggage space: the main modification is that the cooling fan is now driven direct from the end of the crankshaft instead of by belt. For this engine the quoted S.A.E. horsepower is 53 at 4,000 r.p.m, and the maximum torque is 83 lb-ft at 2,000 r.p.m, equivalent to a b.m.e.p. of 138 lb/in².

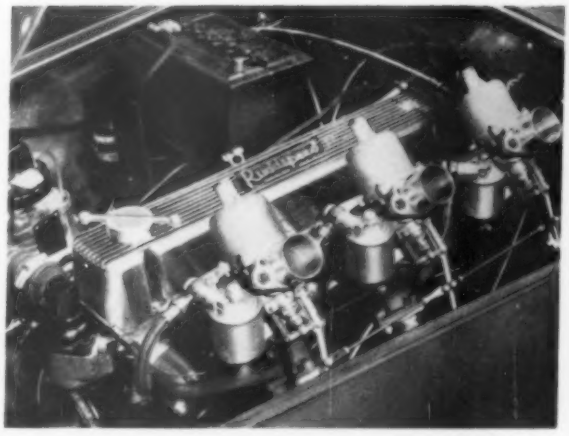
Completely new since the last London Show is the very interesting Lancia Flavia, 1½ litre, horizontally opposed four-cylinder, water cooled engine. This has a four-throw crankshaft carried in three main bearings; the two low

mounted camshafts, which are driven by a duplex chain, are spaced relatively far apart, in order to minimize the length of the pushrods. Bucket type tappets are used and the pushrods actuate rockers, which transmit the movement to inclined valves having the small included angle of 39 deg. The pushrods are of Duralumin tube, with steel inserted ends. Since both the cylinder block unit and the heads are also of light alloy, there should be no problems with regard to differential expansion effects, which with steel pushrods would affect the tappet clearances.

The diecast block and crankcase unit is split vertically on a plane containing the crankshaft axis. Its halves are held together by bolts, which screw into tapped holes having wire thread inserts; some of the bolts are adjacent to the main bearings and there are others around the outer flange. This method of construction has a possible disadvantage in that it involves the incorporation of a vertical joint right along the middle of the oil sump. However, it does give a very rigid bell-housing and, by adding to the beam stiffness of the engine-gearbox unit, must enhance the refinement of running. Both the front and the rear oil seals of the crankshaft are of the spring-loaded lip type; since the rear one works on a diameter of approximately 2⅝ in, its rubbing speed is 3,800 ft/min at 5,500 r.p.m.

The water pump is unorthodox in having a cone-shape impeller running in a conical, machined pocket in the cylinder block. No pick-up volute is used, the water feeding back into a cavity surrounding the pump shaft bearings. A single V-belt drives the fan, dynamo and water pump. It is tensioned by swinging the dynamo: from the accompanying illustration, it can be seen that a single nut is used, tightening on to the dynamo yoke and a slotted strap. This arrangement is an interesting alternative to the end plate extension customary on British dynamos. The fan is positioned behind the belt.

Carburation is effected by means of a Solex or Weber twin-choke downdraught instrument, feeding into a water heated manifold; a breather pipe from the crankcase leads into the duct between the air cleaner and the carburettor. The power output is 78 b.h.p. at 5,200 r.p.m, and the maximum torque of 82 lb-ft corresponds to a b.m.e.p. of 135 lb/in². At 8·3 : 1, the compression ratio is relatively low for an engine with aluminium cylinder heads. The Mahle pistons have 1 in diameter gudgeon pins, so the ratio of that diameter to the cylinder bore is 0·31 : 1. A Hobourn-Eaton oil pump is driven from a spiral gear at the rear end of one of the camshafts, the drive extending upwards to the distributor. Vandervell main journal and connecting rod bearings are used.



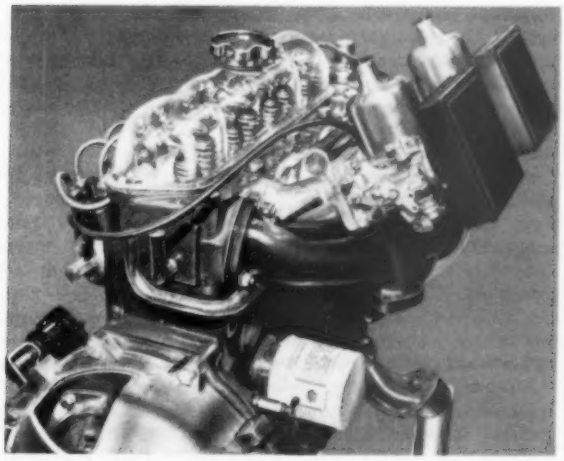
The carburettor arrangement on the A.C. Ruddspeed engine, which has an aluminium alloy crankcase with a cast iron head and liners

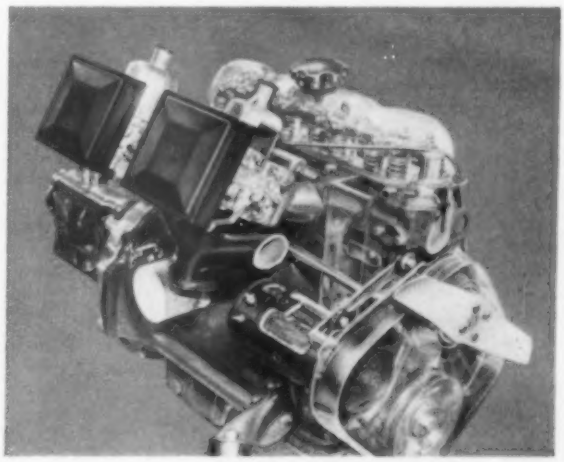
At first glance, this would appear to be an expensive engine to produce, but when one considers its salient features —the diecast cylinder block halves, which obviate the need of bearing caps and a separate sump or bell-housing, the interchangeable cylinder heads and rocker gear covers, the simple water pump and camshaft drive—one realizes that it must actually be a reasonable production proposition. Simplification is obtained by virtue of the water heating of the inlet manifold, since many other horizontally opposed units embody auxiliary exhaust pipes to provide manifold heating to obtain a quicker warm-up. Moreover, the engine mounting difficulties must have been minimized by the inherently good balance of this type of unit.

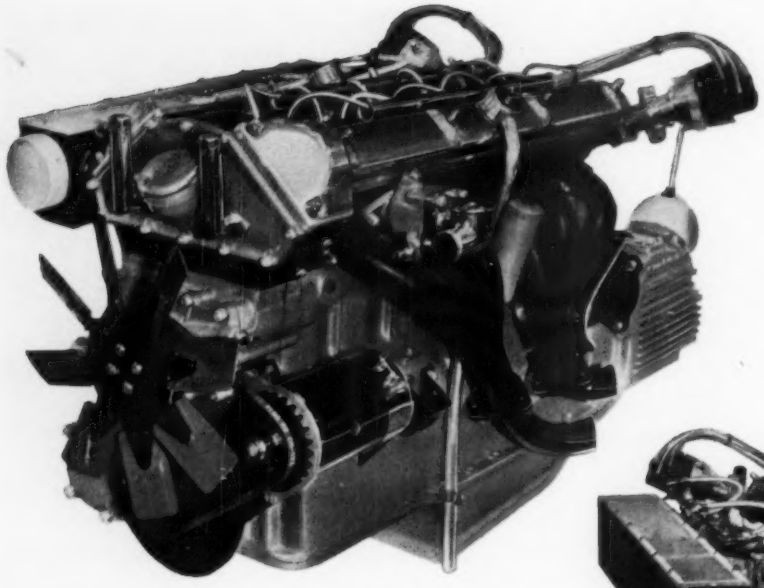
The Fiat 1300 and 1500 engines, which have gone into production during the past year, have a remarkably high specific power output for their type. Their net outputs are 65 b.h.p. and 72 b.h.p. respectively, the gross figures being 72 and 80 b.h.p. respectively. At maximum torque, the b.m.e.p. is 145 lb/in² for both engines, which have a compression ratio of 8·8 : 1 and an aluminium cylinder head.

In effect, these engines are four-cylinder developments of the six-cylinder 1800 and 2100 units; as such, they are

The two views below are of the Volvo 1,780 cm³ engine that is installed in the new P1800 sports coupé, to be assembled in Great Britain by Jensen Motors Ltd. It produces 100 b.h.p. at 5,500 r.p.m. and has a compression ratio of 9·5 : 1. A noteworthy feature is the use of a five-bearing crankshaft







These two views show the latest Aston Martin engine, the oil filler of which is between two breathers, at front of the cylinder head. For the use in the new Lagonda saloon, this unit—the stroke and bore of which were previously 92 × 92 mm—has been bored out to 96 mm; this has increased its swept volume to 3,995 cm³

typical of modern Italian practice. Their basis is a short, cast iron crankcase, the sump joint of which is on the horizontal plane through the crankshaft axis. The valves in the aluminium cylinder head are transversely inclined, in opposite directions, and are actuated by pushrods, rockers, and a camshaft mounted in the crankcase—all very orthodox so far. However, the inlet valves are inclined at 40 deg from the vertical, permitting an inlet port layout of the type normally associated with double overhead camshafts, while the inclination of the exhaust valves is only 8 deg; the combustion chamber form is termed polyspherical by the Fiat engineers, and the layout is similar to that of the Peugeot 404 illustrated in last year's review. No attempt is made to aid combustion by means of piston squish, the diameter of the mouth of the combustion chamber being virtually that of the cylinder bore. The sparking plugs are at a compound angle to the axes of the cylinders, and are on the exhaust side of the head, so the end gas is situated between the inlet valve and the piston crown.

A light alloy timing drive cover is employed. It extends below the crankcase joint face to contain the crankshaft front lip type seal, and it terminates in a semi-circular portion to which the front wall of the pressed steel sump is attached. Lubricant is picked up from the sump through a large, coarse-mesh gauze. It is fed from the pump direct to the front main bearing cap and then, by drillings, into the centrifugal filter mounted on the nose of the crankshaft. From the centre of the filter it enters the nose of the crankshaft and reaches the crankpins and main journals by way of end-to-end drillings in the shaft. This system eliminates the necessity for a full-length gallery within the crankcase. Additional filtration is provided by a by-pass type filter, the bowl of which is mounted horizontally on a facing on the cylinder block, below the inlet manifold.

Crankcase ventilation is effected by a road-draught pipe projecting downward from an outlet on the side of the cylinder block. It was noticed that the six-cylinder versions have a secondary vent pipe from the rocker gear cover. A detail worthy of mention is the coolant drain tap at the rear of the cylinder block; the spindle of this tap has a vertical extension, by means of which the tap can be operated from a point adjacent to the rocker cover. The 12V dynamo has an output of 400W.

On the latest DAF cars, from Holland, a new 746 cm³ twin-cylinder horizontally opposed air cooled engine has been introduced, for export markets, as a successor to the original 590 cm³ unit. The new bore is 85·5 mm but the stroke remains 65 mm, giving a mean piston speed of only 1,700 ft/min at 4,000 r.p.m, at which speed the gross power output is 30 b.h.p. A maximum torque of 42 lb-ft at 2,800 r.p.m. is quoted; it corresponds to a b.m.e.p. of 139 lb/in². As before, the compression ratio is 7·1 : 1.

The crankcase is made in two halves and, like the Lancia unit, is split vertically through the crankshaft axis, again obviating the need for a separate sump. Each of the finned cast iron cylinder barrels spigots into the crankcase, into which are screwed the long studs that retain the light alloy heads. The gear driven camshaft is mounted directly below the crankshaft and operates long, mushroom type tappets, to which oil is fed under pressure; advantage is taken of this arrangement to lubricate the valve gear, by way of the light alloy pushrod tubes. To prevent burning and to prolong seat life, the valves are free to rotate.

Plain bearings are used for the main and big-end journals, which are induction hardened. A gear type oil pump, driven from the end of the camshaft, delivers oil from the 3½ pint sump through a crankcase-mounted filter to the bearings. A novelty to DAF is that the cooling fan is fitted to the crankshaft; ducting directs the air over the barrels and heads. The impeller of the fan is of the double-sided type, and the air reaching it from the rear has first to pass over a rather fragile-looking coiled pipe that is the oil cooler. Since this pipe is not finned in any way, a considerable number of coils is necessary to provide adequate surface area. The position of the cooler, in front of the pulley, would seem to make the changing of the dynamo belt a major operation.

This is another of the Continental engines on which a warm air intake is provided for winter conditions, to prevent carburettor icing. In this case, the air is picked up from a region adjacent to the exhaust outlet from one cylinder head, and is fed to the air cleaner, which has an adjustable flap allowing the choice of a hot or cold air intake. Car interior heating is provided by leading some of the cooling air—after it has passed over the engine—through ducts surrounding the exhaust pipes, and thence to the interior of the car; the ducts embody insulation against noise.

During this year, Chevrolet has announced two new engines for its compact cars; one is a four-cylinder unit of 2½ litres swept volume and the other a six cylinder one of 3·2 litres. The four-cylinder unit is typical of the two, and has bore and stroke dimensions of 3·875 in × 3·25 in; its power output is stated to be 90 b.h.p. This engine has the remarkably low weight of 360 lb, and is claimed to be 10 lb lighter than the MGA 1600 Mk II unit. For further comparison, the Coventry Climax 2½ litre four-cylinder racing engine, with aluminium block and head, weighs 310 lb, complete with starter and dynamo.

This low weight represents an amazing achievement by Chevrolet, especially in view of the massive five-bearing crankshaft and the cast iron cylinder block, which admittedly does not extend below the horizontal plane through the crankshaft axis; the cylinder head also is iron. Otherwise, the engine is conventional in most respects: it has a pressed steel sump and rocker cover, and the pushrod operated, in-line valves are slightly inclined. The rockers, too, are pressed steel and are carried on hemispherical pivots. This type of rocker was, of course, first used some years ago by Chevrolet on its V-eight engines.

In connection with the low weight of this power unit, an interesting point arose during a discussion with an engineer from a prominent British foundry. He stated that, owing to the better flow characteristics of the iron ore available in the U.S.A. foundries they can, in fact, produce castings with appreciably thinner sections than are practicable in this country. It is unfortunate, in view of this comment, that details of the section thicknesses at various parts of the Chevrolet casting could not be obtained in time for comparison in this review.

Enlarged and uprated engines

For the latest Aston Martin cars, a special version of the familiar 3,670 cm³ six-cylinder engine is available. The power output of this unit has been increased from 240 to 262 b.h.p, primarily by the adoption of three carburettors mounted on a water heated inlet manifold. For sustained high-speed running, the company recommends the optionally extra oil cooler, as fitted to the DB4GT car.

For use in the new Lagonda saloon, this 92 mm × 92 mm engine has been bored out an extra 4 mm, to increase its swept volume to 3,995 cm³. In this form, fitted with two Solex compound carburettors on a water-heated manifold, the unit has a net power output of 236 b.h.p. at 5,000 r.p.m. The maximum torque of 265 lb-ft at 4,000 r.p.m. corresponds to the extremely good b.m.e.p. of 178 lb/in², which is achieved with a compression ratio of 8·25 : 1. On this engine, the oil filler cap, which is situated between the two new breathers on top of the front cover, would seem to be badly sited: a careless garage attendant could easily spill oil on to the belt that drives the fan and dynamo.

Owing to the employment of a light-alloy cylinder block and head, both versions of this impressive engine must be relatively light. The crankshaft, which is nitrided, has seven main bearings. Twin overhead camshafts, driven by a duplex chain, actuate the inclined valves through the medium of tappets made of cyanide-hardened nickel-molybdenum steel. Good heat transfer from the hottest regions of the engine is ensured by having the exhaust valve guides in direct contact with the coolant in the cylinder head jacket.

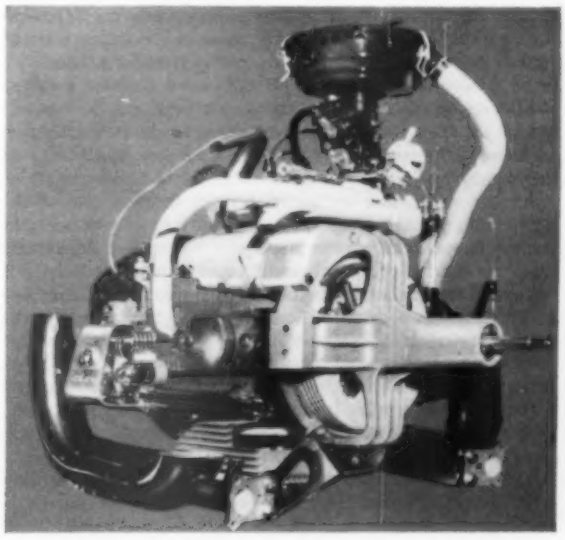
The British Motor Corporation offers a considerable variety of engines, most of which have been uprated in some way. The ADO 50 Cooper models have a new version of the Series A engine; it has a swept volume of 997 cm³, derived from a slightly reduced bore of 62·4 mm and a longer stroke of 81·3 mm. This unit develops 55 b.h.p. at 6,000 r.p.m, and a maximum torque at 3,600 r.p.m. of 54 lb-ft, equal to a b.m.e.p. of 134 lb/in². Its compression ratio is 9 : 1. The cylinder head assembly is similar to that of the latest Austin-Healey Sprite, which has larger inlet and exhaust valves than before. All the crankshaft bearings are now of copper-lead, with an indium flash. Twin S.U. carburettors and a new exhaust system of free-flow design are used.

An S.U. carburettor is now fitted to the engine of the Austin A.40 Mark II. In consequence, the power output has gone up, by 3 b.h.p, to 37 b.h.p. The swept volume of the Series B engine has been increased to 1,622 cm³, by enlarging the bore only, for installation in the A.60. Solid-skirt pistons are now employed, the crankshaft has been stiffened and the inlet and exhaust valves are of larger diameter. The net result of these changes is an increase in power from 53 b.h.p. to 61 b.h.p. In the case of the 2,912 cm³ engine, as used in the Austin A.110, the power has risen from 108 to 120 b.h.p, by virtue of a new camshaft and valve springs, in addition to a new twin-pipe exhaust system.

Surprisingly, although all the B.M.C. engines mentioned have iron cylinder heads and vary so much in cylinder size, they all have a compression ratio between 8·2 and 8·3 : 1, except the ADO 50 which has a 9 : 1 ratio. The power output of the basically Series A engine of the Austin-Healey Sprite Mark II has been raised to 46·5 b.h.p. at 5,500 r.p.m. On the Austin-Healey 3000 model, the output has also been increased, to 130 b.h.p: three S.U. 1½ in carburettors are now specified, together with a redesigned camshaft and stronger valve springs.

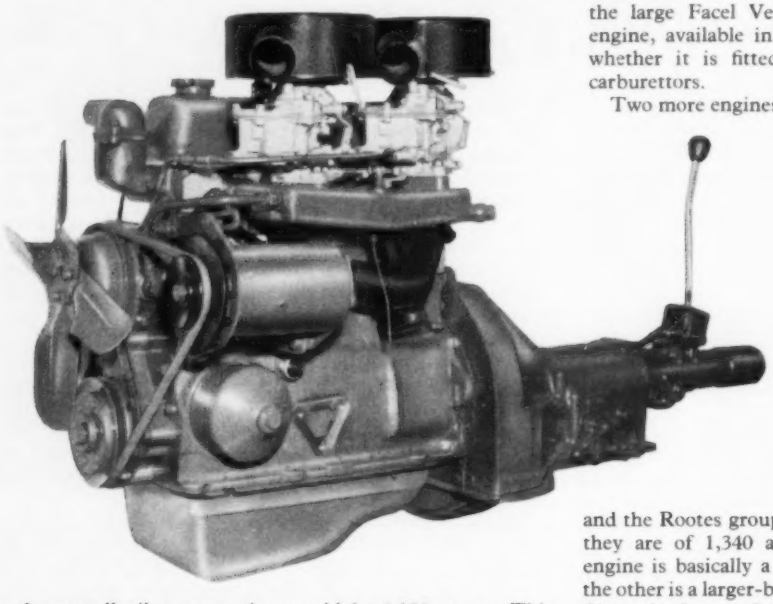
This year, Auto-Union has introduced a 796 cm³ version of its three-cylinder two-stroke engine, though the 741 cm³ unit remains in production. The new engine has bore and stroke measurements of 70·5 mm × 70·5 mm, as against the 68 mm × 68 mm of the smaller model. Indicative of the state to which the modern two-stroke engine has been developed is the fact that the 796 cm³ unit has a maximum torque of 52·5 lb-ft at 2,500 r.p.m, which is comparable

DAF air cooled engine, with cast iron cylinders and aluminium heads



with the figures of 53 and 54 lb-ft for the Austin-Healey Sprite and the ADO 50 respectively; it is virtually the same as the torques of the Fiat 1100 special series engine and the Ford 105E unit of 997 cm³. Measured under SAE conditions, the maximum power output is 39 b.h.p. at 4,000 r.p.m.

A noteworthy feature of the engine is the Lubrimat lubrication system, which has reduced the oil consumption to 1 per cent of the fuel consumption; to use the conventional two-stroke terms, the average petrol to oil ratio is 100 : 1, a considerable advance on the previous ratio of 40 : 1, which itself was good compared with that of many of our motor-cycle two-stroke engines. On the basis of a fuel consumption of 40 m.p.g.—probably a conservative figure in this application



Neat oil filter installation on the Vauxhall VX 4/90—an arrangement that is relatively widely used. A new feature is the plastics pulley for the dynamo

—the overall oil consumption would be 4,000 m.p.g. This consumption, of course, cannot vary appreciably as piston rings or valve guides wear, as it does in a four-stroke engine, and no account has to be taken of oil and oil filter changes, neither of which is required with this total-loss scheme.

The Lubrimat system consists of a small, belt driven pump that feeds oil in metered quantities from a 6½ pint supply tank to the engine, the quantity depending on engine speed and throttle opening. Since the oil is fed into the emulsion tube of the carburettor, downstream of the main jet, the engine is still in fact operating on a petroil mixture. To provide adequate lubrication for prolonged downhill running at high speed, the idling system also is arranged to feed the petroil mixture to the engine. Incorporated in the system is a dashboard warning light that indicates any failure in the supply.

In this interesting engine, the main bearings are of the roller type, grease packed and sealed for life. Roller bearings are employed also for the big ends; they have Aloxidized cages to combat the crankcase corrosion which has been a source of trouble in many two-stroke units. Needle roller bearings are employed in the small ends. Surprisingly, the high sparking frequency still seems to be something of a problem: in this case, three separate ignition coils are used, and they are served by three contact-breaker units mounted on one baseplate, with individual adjustment of the timing. The sparking plugs are of the so-called thermo-elastic type, either Bosch M175TL or Champion UK10.

Citroën has again uprated the well known DS 1,911 cm³ four-cylinder engine. The latest power output of this long-stroke unit is 83 b.h.p. at 4,500 r.p.m. Another attraction on the Citroën stand at Earls Court was the new Ami 6, powered by a 602 cm³ horizontally opposed, air cooled twin-cylinder engine producing 22 b.h.p. at 5,000 r.p.m. This unit closely resembles the smaller, 2CV engine but has a less restrictive induction system.

One of the few production engines with twin overhead camshafts is that of the Facel Vega Facellia. It is a four-cylinder unit and has a swept volume of 1,646 cm³. Despite the employment of only a single downdraught carburettor, which is of Solex manufacture, its claimed gross power output is 115 h.p. at 6,400 r.p.m. Among the changes made since last year are the adoption of a stronger crankcase, copper-lead bearings for the jockey sprocket of the camshaft chain drive, and a modified water pump. Also shown was the large Facel Vega car, which has a Chrysler V-eight engine, available in 330 or 360 b.h.p. form, depending on whether it is fitted with one or two Carter four-choke carburettors.

Two more engines of increased capacity are the Ford 109E and the Rootes group unit fitted to the Hillman Minx 1600; they are of 1,340 and 1,592 cm³ respectively. The Ford engine is basically a 105E Anglia with a longer stroke, and the other is a larger-bore version of the familiar 1½ litre model. Since the bores of the two are almost identical, at 81 and 81·5 mm respectively, it is reasonable to assume that the swept volume of the Ford engine might again be increased to 1,600 cm³. The maximum b.m.e.p. of both engines is 131 lb/in², and both are again similar in having cast iron crankcases and cylinder heads, pushrod operated overhead valves and single downdraught carburettors. Both are equipped with Hobourn-Eaton oil pumps, and each has a gross output of 57 b.h.p; the 109E, however, develops its maximum power at 5,000 r.p.m. while the Rootes unit does so at 4,100 r.p.m. An alternative version of the last-mentioned engine is installed in the new Super Minx saloon. It develops 66 b.h.p. gross at 4,800 r.p.m, the increase being derived primarily from a camshaft having greater overlap.

The almost incomparable Jaguar engine in its latest 3·8 litre form—as employed in the Mark X and E Type cars—has an output of 265 b.h.p, for the attainment of which three S.U. carburettors are fitted. The cylinder bores in the cast iron cylinder block have interference-fit sleeves, which are finish machined in position. To improve cooling at the top of the siamesed bores, slots are machined to separate the cylinders for the upper part of their depth, thus allowing water to circulate all round the bores in the region of maximum heat flow. With a 9 : 1 compression ratio, the maximum b.m.e.p. is 172 lb/in² at 4,000 r.p.m.

Mercedes-Benz is a name that conjures up visions of the past—of a big engine with a Roots type supercharger that was brought into action by full depression of the accelerator, with a resultant jet of black smoke from the tail pipe. The modern Mercedes is a far cry from its forebears, but technically is just as interesting: three sizes of petrol engine

were on show at Earls Court: their swept volumes are 1,897, 2,195 and 2,996 cm³. On the two larger engines, there is a choice of fuel injection or carburettors. A feature of all the Mercedes-Benz engines is the use of a single overhead camshaft, which actuates the valves through the medium of rocking fingers.

The lubrication of the valve gear of the 1·9 litre four-cylinder engine has been modified. Briefly, oil is fed under pressure to the camshaft front bearing, from which a metered flow is led into a gallery tube situated alongside the camshaft. This tube is drilled at intervals, the holes providing a drip feed to the other bearings and the cams. An advantage of this system would seem to be that axial drilling of the camshaft is obviated.

A light alloy cylinder block and head are features of the 300SE, 2,996 cm³, six-cylinder engine. The final choice of iron press-fit cylinder liners was made only after thorough tests with both chromium plated bores and cast-in liners. In the event of excessive wear or damage to the block, it has to be serviced at the factory, since the liners are not thick enough for reboring. Before fitting, the liners are shrunk by immersing them in liquid oxygen. To increase valve and seat life, Rotocap valve rotators are fitted to all inlet and exhaust valves, while the valve stems carry Teflon sealing rings.

The 220S car has a 2·2 litre, six-cylinder engine with an iron cylinder block and two Solex carburettors. A noteworthy feature is the provision of a cold or warm air inlet system. The selection of cold or warm air, for winter or summer running, is effected by a flap valve with a manual control. In hot weather, the control can be locked in the cool air position, but for normal ambient temperatures it can be set to supply heated or cool air, according to the manifold depression.

A Show surprise by Sunbeam was the introduction of performance-improvement kits for the Alpine model, the 1,592 cm³ engine of which, in standard form, develops 86 b.h.p. gross at 5,000 r.p.m. Six different kits are offered: the first two are to increase the output of the engine, the third consists of an oil cooler installation, and the other three are respectively for the brakes, the chassis and the rear axle. The stage 1 engine kit includes a high lift camshaft, a replacement distributor and a number of carburettor items. Embodiment of these components raises the gross power output to 101 b.h.p, a very satisfactory figure for a 1·6 litre engine with pushrod operated valves. For comparison, the Porsche 1600 Super 90 engine gives 102 b.h.p. gross at 5,500 r.p.m. The stage 2 kit consists of a lightened flywheel, a special clutch assembly and an engine stabilizer. As would be expected, the oil cooler installation can be purchased with or without either of the other kits. It is significant that engines with these modifications have now been employed by the Rootes competitions department for some two years—a major success was the winning of the Index of Thermal Efficiency award at Le Mans this year—and the introduction of these kits reflects the confidence of the Rootes group in its standard products.

The new Triumph Herald 1200 engine is a good example of the conscientious way of increasing the swept volume while sacrificing very little of the original design parameters. In this instance, the increase from 948 to 1,147 cm³ has been effected by an increase in the cylinder bore from 63 mm to 69·3 mm, the stroke remaining at 76 mm. Naturally, where an engine is in quantity production, the capabilities of the machining equipment must be taken carefully into consideration in a change of this nature; in this case, the cylinder block has the same outline as before, but the distances between cylinder axes have been increased and—as viewed in plan—they have also been offset in relation to the crankshaft. Copper-lead-indium bearings are now used, the crankshaft had been stiffened by the adoption of more robust flying webs, and a full-flow oil filter with a paper element is specified.

In its standard form, the engine produces 43 b.h.p, but this output can be substantially increased, to 60·5 b.h.p. at 5,800 r.p.m, by means of a kit, which was announced for the London Show and is available to owners of Herald 1200 cars. This kit consists of twin S.U. carburettors, a redesigned camshaft, new inlet and exhaust manifolds and valves, a new exhaust system and a modified distributor. The compression ratio is raised to 8·5 : 1 by machining the cylinder head.

With their VK 4·90 1½ litre car, Vauxhall Motors have entered the sporting saloon car class. This latest model is based on the new Victor, but has a 44 per cent greater power output from the same size of engine; this increase has been obtained by the use of an aluminium cylinder head, twin Zenith downdraught carburettors, a new camshaft profile and modified cylinder head ports. The compression ratio is 9·3 : 1. To assist in maintaining the gross power output of 81 b.h.p. without premature failure, the valves are aluminized, a treatment in which a thin coating of aluminium is deposited over the valve head. This process has not previously been applied in Great Britain, although it was advocated by Harry Weslake during the 1939-45 war, when fairly heavily leaded fuels were used.

A number of points of technical interest, not covered in the foregoing, are listed below:

The water heated inlet manifold of the Fiat 1100 is positioned immediately above the exhaust manifold—should it be regarded as water cooled?

No new engine approaches the stroke : bore ratio of the Ford 105E at 0·6 : 1, or the American Ford Falcon at 0·715 : 1

Vandervell Products Ltd. are producing large quantities of pressed steel rockers for the small B.M.C. engines

General Motors claim that the main bearings in their Cadillac V-eight engine are selectively assembled, to develop closer fits

In the Buick aluminium V-eight unit, the compression ratio is 11 : 1

The new Chevrolet 90 b.h.p. engine is the first four-cylinder unit to be produced by this company since 1928

The Ferrari 400 Superamerica was the most powerful car, its engine developing 400 b.h.p. gross at 6,750 r.p.m; the least powerful was the Citroën Bijou with 12 b.h.p. gross—the same power as the original Austin Seven

A Simms exhibit was the Mark II petrol injection pump, installed on an 845 cm³ engine and belt driven

On the C.A.V. stand, a coloured cine-film was demonstrated, showing the actual sequence of combustion within a diesel engine

The same company exhibited a tamper-proof excess fuel device

In view of the increasing loadings in engines, the Glacier, reticular tin-aluminium bearings are attracting more interest

Redex Ltd. has introduced Diesel Deodorant, claimed to deodorize diesel fuel and so to be of particular value in the case of cars with diesel engines

Electrically driven cooling fans with thermostatic switches were seen on several accessory stands as well as on the E Type Jaguar and Lotus Elite

Another cooling development is an engine driven fan with a temperature-sensitive clutch: the drive engages only when a predetermined temperature has been reached

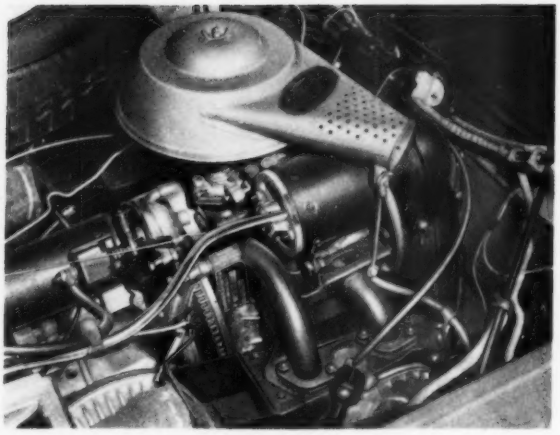
Autolite starter motors can be fitted with a centrifugal clutch mechanism to prevent the starter pinion from alternating in and out of engagement

For high performance engines, the use of 21-4NS valve steel is increasing

A new development is the heat stabilizing of valve springs, to prevent loss of rate owing to the effect of hot oil; this loss can occur at temperatures that are as low as 80 deg C.

Carburation and Induction Systems

Little Change in the Basic Approach but a Continued Demand for Increased Breathing Capacity; Improvements in Fuel Pumps and Throttle Control Systems

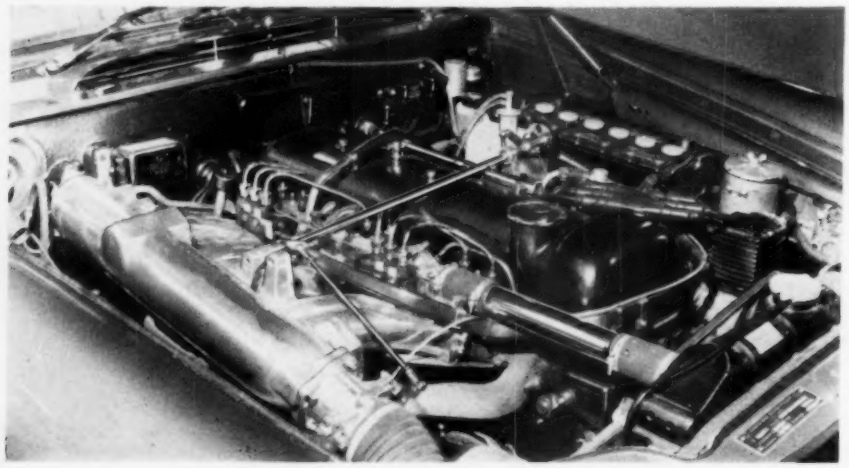


On the Citroën Ami 6, a single Solex downdraught carburettor feeds into the centre of the long induction tract which, to prevent neat fuel passing to the cylinders, sweeps up from the exhaust-jacketed section beneath the riser and then down again to the inlet ports

FUEL systems for road vehicles in general and passenger cars in particular have not changed greatly in recent years, and the exhibits at the London Show offer little that is really new. While British and Continental power units tend to become larger, in the pursuit of increased power and torque, those of the American cars tend to become smaller, as the popularity of the so-called compact car increases. In the U.S.A, however, there is a trend to increase the output of the compact car engines, so on all sides there is a demand for larger carburettors and breathing areas.

On American exhibits the automatic choke was almost universal. On the Continental models, too, there was evidence that the popularity of this device is increasing, but the situation remains almost unchanged in respect of British cars. A few models were equipped with some type of automatic cold-starting system, but the numbers of such cars is still small. Compound carburation systems, in which several throttle valves open progressively as more power is required, are widely used on American engines. Recently, this system has been featured increasingly on Continental models, and this year's Show indicates further gains. Nevertheless, from a review of the British exhibits, it would seem that where the more highly-rated engines are concerned, the requirements are usually met by the use of two or more carburettors of the constant-vacuum design. The power units of the Jaguar E Type and Mark X saloon are typical examples of this school of thought. Although the S.U. carburettor remains the sole available example of the expanding-choke type of metering instrument, it is not unlikely that this field will be widened. Indeed, it has already been announced in the U.S.A. that the Bendix Corporation has developed a Stromberg carburettor of the constant-vacuum type.

Petrol injection has not fulfilled the promise of a few years ago, and again at the London Show the only vehicles fitted as standard with injection equipment were the Mercedes-Benz 300SE and 220SE cars. Both these models had the later form of Bosch metering, in which a two-plunger pump replaces the six-plunger unit originally employed. Briefly, each pump plunger feeds a small fuel manifold, and each manifold supplies the injection nozzles of three cylinders, the nozzles being located in the inlet ports. Thus, instead of the fuel charge being metered and injected into the inlet port of each cylinder on its suction stroke, three ports receive their charge simultaneously, regardless of the portion of the cycle over which they are functioning at that instant. Various control elements—one of which is a centrifugal governor—serve to regulate the delivery of the pump according to engine requirements. On the latest versions of this system, more use is made of electrical



Bosch twin-plunger injection pump installation on the Mercedes-Benz 300SE. Each plunger feeds a small fuel manifold and each manifold supplies simultaneously the injection nozzles in the inlet valve ports of three cylinders

circuits for controlling the cold start and warm-up devices.

The Rochester petrol injection equipment has been an optional extra on the Chevrolet Corvette, but this model was not exhibited, nor was the Maserati 3,500 G.T, which has the Lucas shuttle type device. On the Simms Motor Units stand, an engine was shown equipped with the Simms injection system, in which a pumping element driven by the engine delivers metered fuel to a single discharge nozzle located in the induction manifold riser. This unit was described in last year's Show Review issue of *Automobile Engineer*. Metering is effected by a spill device, which is governed by controlling elements influenced by engine r.p.m, manifold depression and temperature.

Fuel pumps

For many years there have been only two main types of fuel pump: they are the engine-driven, mechanically operated diaphragm pump, of which the AC is a common example, and the electric type, the most widely known of which in Great Britain is the S.U. diaphragm unit. Within the last few months, however, two new types of electric fuel pumps have made their appearance, and were exhibited at Earls Court. One of these is the new Lucas 2FP pump, which is fitted as standard equipment on the Jaguar E Type and Mark X cars.

Following aircraft practice, this pump unit is intended for installation in a submerged position in the fuel tank. It is thus kept cool and, since the intake is at the bottom of the tank and therefore under a gravity head of fuel, there is little pressure drop on the suction side of the pump to induce the formation of vapour. The delivery side, of course, is under pressure, so the possibility of vaporization is virtually eliminated. This interesting unit was fully described in the July issue of *Automobile Engineer*. Consequently, there is no need to say more at this juncture than that it is of the continuous delivery type, in which a peripheral-flow impeller is employed.

The other newcomer to Europe is the American Bendix electric pump. This unit is, however, well known in the U.S.A, and was described in the September 1953 issue of *Automobile Engineer*. It is installed on the Lancia Flavia, and has recently attained some prominence in Great Britain because of its being employed on certain racing cars; for example, the Lotus-Climax driven by Stirling Moss when he won the Monaco Grand Prix earlier this year. The unit is a simple device, functioning on the lift-pump principle.

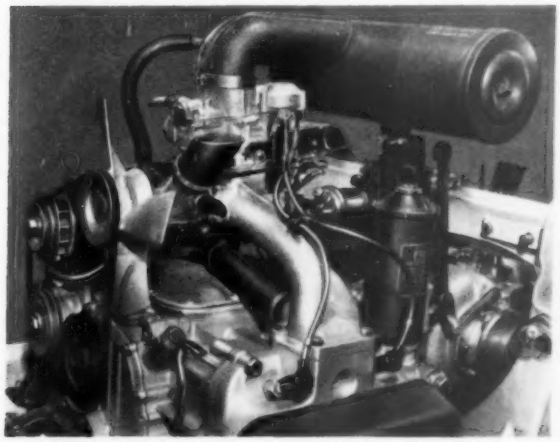
To actuate the make-and-break contacts, a solenoid and a permanent magnet are employed. At the maximum rate of fuel delivery, about 25 gal/hr, the current consumption is only 0·6 A at 12 V. The electrical components are sealed hermetically in an inert gas, to avoid the risk of fire. A feature of the pump is its accessibility: on the extraction of the base piece, which has a bayonet fastening, the filter unit, plunger and valves can readily be removed for cleaning and examination. The casing is of cadmium plated steel, and fuel entering the pump unit flows over a magnet to remove any ferrous particles.

Four-cylinder engines

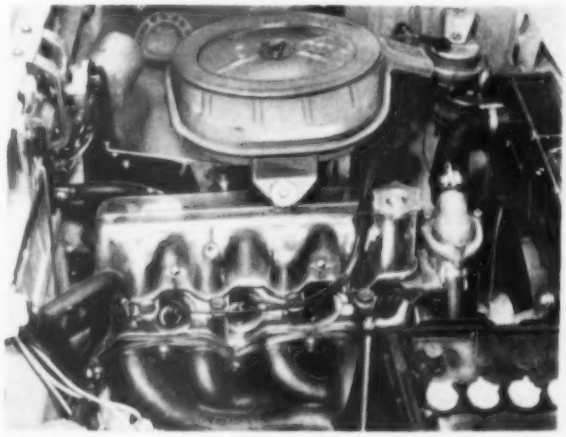
The Ford 109E engine of the Classic 315 and Capri cars has the same bore dimension, 3·187 in, as the 105E Anglia unit, but its stroke is 2·562 in instead of 1·90 in, so the swept volume has risen from 997 cm³ to 1,340 cm³. Although the inlet and exhaust valves are the same size as in the 105E engine, the area of the induction tract has been increased. Externally, the induction manifold casting looks much the same as that of the smaller unit. It is, of course, a four port branch system of the so-called straight-rake pattern, and the port branches descend from the main gallery to the valve ports. A small, exhaust heated hot spot is provided where the two manifolds are bolted together. There are also minor alterations to the exhaust manifold.

Increased breathing capacity is furnished by the use of a Zenith 32-VN2 downdraught carburettor with a 2 mm larger choke than has the Solex instrument on the 105E unit. The Zenith carburettor incorporates an acceleration pump and an automatic economy system for low petrol consumption in cruising conditions. Cold starting is effected by the usual Zenith semi-automatic strangler valve, interconnected with the throttle to provide a fast idle. As on the Anglia, fuel is supplied by an AC mechanical pump. A large-diameter, pan-shape air cleaner, with a single silencing tube, fits directly on to the intake of the carburettor. From the exhaust manifold, the discharge pipe is led downward and to the rear, on the left-hand side, into two silencers in series.

The Rootes 1,592 cm³ engine, with bore and stroke measurements of 81·5 mm × 76·2 mm, is now fitted to the Hillman Minx and Super Minx, the Singer Vogue and Gazelle, and the Sunbeam Alpine and Rapier. As in the case of previous, smaller power units, the inlet and exhaust manifolds are on the left-hand side, with the inlet one uppermost. The two are bolted together to provide an exhaust-heated hot spot. A twin-gallery carburettor delivers into a mixing chamber below. From this chamber, a



A generously proportioned jacket for the engine-coolant heating of the induction manifold is a feature of the Lancia Flavia design



In the exhaust manifold of the Fiat 1300 and 1500 models, the tracts of numbers 1 and 4 cylinders are separated from those of 2 and 3

gallery tract runs longitudinally in each direction for a short distance, then branches into two side-by-side channels. Each pair of tracts then turns inwards to the separate valve ports in the cylinder head; it follows that, from a point close to the carburettor outlet, each valve port is fed by its own tract.

On the version in the Super Minx, a Zenith 32-VN downdraught carburettor is installed; it is a little shorter than the 32-VN2 instrument on the Ford 109E engine, but also has the automatic economy system, acceleration pump, semi-automatic strangler and linked fast idle device. An AC paper-element air cleaner fits directly to the intake of the carburettor, and its silencing tube points forward. Fuel is supplied by an AC mechanical fuel pump mounted low down on the right-hand side of the crankcase.

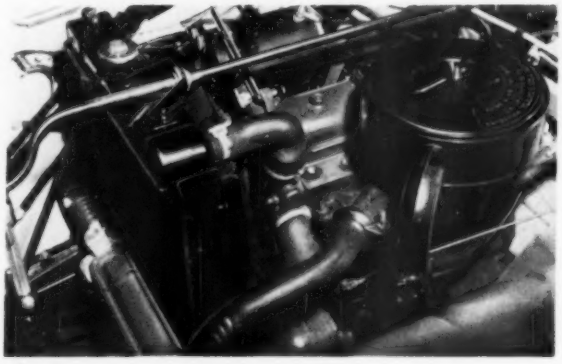
In the case of the Hillman Minx 1600 Series 3C and the latest Singer Gazelle, the smaller Zenith 30-VN carburettor is adequate. This is because an earlier type of camshaft is employed and the peak torque therefore occurs at a lower engine speed. The induction and exhaust systems are similar to those of the Super Minx. Although the engine of the new Singer Vogue is mechanically identical with the Super Minx unit, the carburettor employed is a Solex 32-PBI downdraught instrument. Here again, an acceleration pump, off-set strangler and linked fast idle system are embodied.

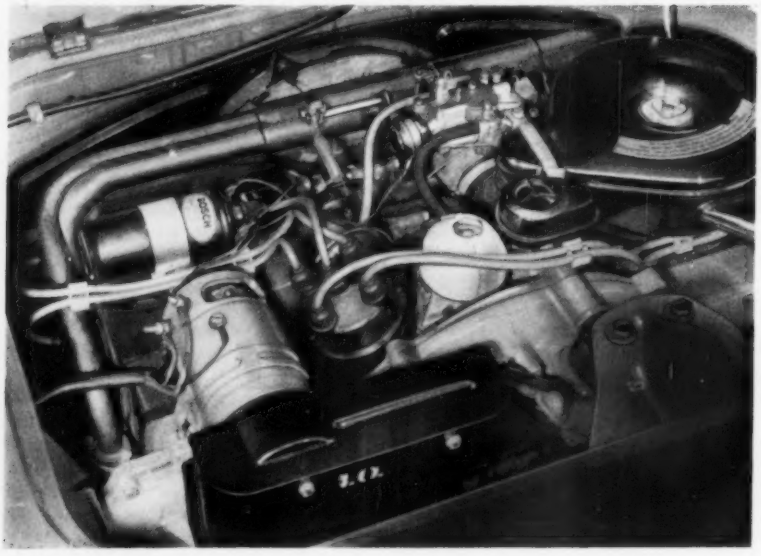
As has already been indicated in the Engines section of this review, the horizontally opposed four-cylinder 1½ litre engine of the Lancia Flavia is one of the most interesting new units exhibited at Earls Court. Each inlet valve has its own port on the upper face of the cylinder head. A Solex or Weber twin-barrel, compound carburettor is used, feeding into the middle of the long aluminium induction manifold. This has a circular cross section, and each gallery tract runs laterally to the appropriate pair of cylinders in the conventional manner for this layout. The engine coolant is employed to heat the mixture, and the riser junction in the middle of the manifold is jacketed for this purpose. Hot coolant is fed from the top of each cylinder head, through lengths of rubber hose into the riser jacket; another length of hose transfers the coolant from the jacket to the top of the radiator. An air cleaner of long cylindrical form, mounted horizontally above the engine, is connected by a metal elbow to the carburettor intake.

In this carburettor installation, the primary throttle barrel —for light-load and cruising conditions—is on the left. The secondary throttle barrel is brought into effect, when necessary, by a large diameter, vacuum actuated diaphragm assembly, mounted on top of the carburettor. As already mentioned, the fuel pump is the American Bendix electric unit. It is mounted in the boot, which is doubtless the coolest and most convenient place for it.

Another new Continental engine to be equipped with a compound downdraught carburettor is that of the Fiat 1300. In this instance, however, the progressive compound action is obtained by a mechanical linkage between the primary and secondary throttle valves. The carburettor, a Solex C28-32PAIA unit, is situated on the left-hand side of the engine, and supplies a double-gallery induction tract formed in a single aluminium casting. One gallery links cylinders 1 and 4, while the other connects cylinders 2 and 3; both are fed from a central mixing chamber, into which the carburettor delivers its mixture. The induction casting is water-jacketed round the central portion to provide a hot spot. Fuel is fed from the mechanical pump through a stout plastics pipe to the carburettor. The use of plastics fuel pipes is widespread on the Continent, but is less favoured in the United Kingdom.

An unusual design of exhaust manifold is employed. Exhaust systems that separate the tracts of cylinders 1 and 4 from those of cylinders 2 and 3 are relatively common today, but on the Fiat 1300 and 1500 engines this separation has been effected in a single manifold casting. At the rear of





Above: On the Renault 4L, the inlet and exhaust manifolds are formed by a single fairly large casting. With this arrangement, there certainly should be no lack of heat for the mixture in cold winter weather

Right: The carburation assembly for the E Type Jaguar is indeed impressive. Of particular interest is the careful design of the control linkage system for throttle actuation

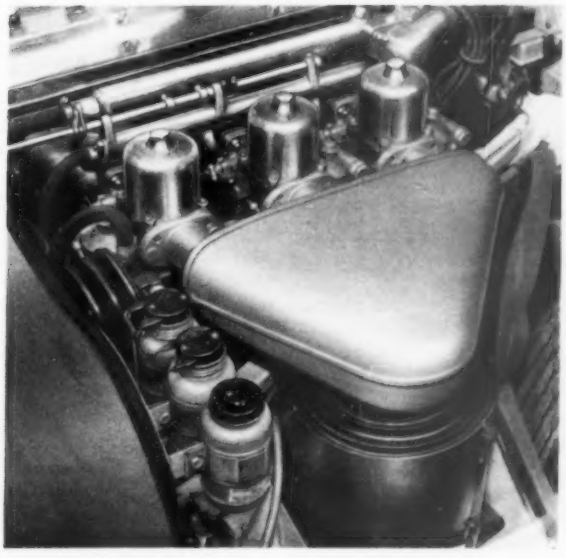
Left: The Volkswagen 1500 engine layout is more compact than that of the preceding model. It features a new Solex horizontal carburettor, which supplies a long, exhaust heated, cross-over type induction tract

the casting is a single down-pipe flange with two outlets. The tract from cylinder 1 runs rearward to join that from cylinder 4, while the separate tracts from cylinders 2 and 3 also run to the rear and pass underneath the first tract. Although a good example of foundry work, the casting is rather massive and might be expected to become very hot. From the outlet flange, twin down-pipes extend downward and to the rear, where they merge into a single pipe just ahead of the first of the two silencers.

The engine of the Volkswagen 1500 in many respects closely resembles its smaller predecessor, but differs from it in respect of the induction system. To minimize the overall height of the unit, a new Solex 32-PHN horizontal carburettor is now employed instead of a downdraught instrument. The carburettor feeds the long induction tract, which is disposed transversely to supply the two pairs of opposed cylinders. A hot spot is provided by the junction with the cross-over exhaust system. For cold starting there is an automatic choke with an electrically heated thermostat unit, and the carburettor incorporates an electrically controlled device that opens a large vent to the float chamber when the ignition is switched off. This is a particularly desirable feature for an air-cooled engine. An unusual detail is the plastics cover on the fuel pump, designed to shield it from radiated heat.

It is many years since a 90 deg V-four engine was exhibited at Earls Court. Such a unit is installed at the rear of the Zaporogets, a small Russian car. The K-123 downdraught carburettor, which has a small choke, is mounted on a transverse induction manifold feeding siamesed inlet ports in each cylinder bank. An air cleaner is fitted on the right-hand side, connected by trunking with the intake of the carburettor, in the usual manner. Since, on the model exhibited, a sheet metal cover enclosed the angle between the cylinder banks, it was not possible to ascertain the type of mixture heating employed.

Probably the most generous induction hot spot to be seen at the Show was that on the 747 cm³, four-cylinder engine of the new Renault 4L. The induction and exhaust manifolds are integral, in a single casting on the left-hand side of the engine. Of the two, the lower is the induction manifold, which feeds the two siamesed inlet ports and is supplied with mixture by a small Solex 22-IDS downdraught carburettor. Above is the four-port exhaust manifold, the off-take flange of which is at the front. Surmounting the



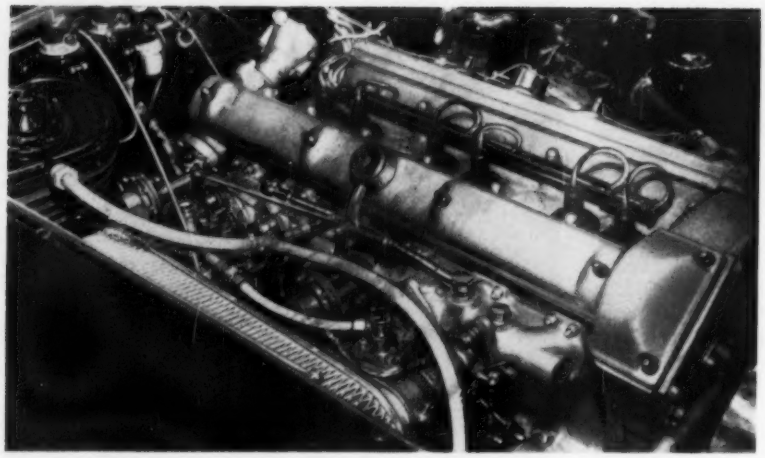
Twin Zenith 36WI downdraught carburettors on the Vauxhall VX 4/90

carburettor is a pan-shape air cleaner with a silencing spout. It would appear that the air cleaner can be rotated to bring the spout to the rear as a means of preventing icing in winter, but with such a well-heated induction tract there should be little risk of this trouble.

On the new Vauxhall VX 4/90, the increased power output requirement has led to considerable modifications to the induction system in comparison with that of the Victor. Although the inlet ports of cylinders 2 and 3 are adjacent, the exhaust ports of each pair of cylinders are separated by the inlet ports of the end cylinders. Both the manifolds remain on the left-hand side of the engine, but two carburettors are employed: they are Zenith 36-WIA downdraught instruments, which feed a common tract with four separate port branches. These branches are not spaced equally along the main tract: the two outer ones turn sharply inward towards the cylinder head, whereas the two inner ones diverge towards the head; where they leave the main gallery they are separated by only the thickness of the casting wall. At this point, therefore, the tract has a relatively large cross-sectional area.

Engine coolant is employed to heat the mixture. Two connecting coolant passages are arranged on the outboard side of the induction manifold, and their openings are at the front. The upper opening is connected by a flexible pipe to the thermostat housing, and the lower one to the water pump. A good feature of this design is the use of separate studs and nuts to attach the induction manifold, which should ensure a leak-free joint. Each carburettor has its own paper element air cleaner, which fits directly on to the carburettor intake; the silencing tubes point towards the front left-hand side of the car. A breather pipe connects the engine rocker gear cover with the outer chamber of the rear air cleaner.

It was surprising that so large a vehicle as the Chevrolet Chevy II should be powered by a 2,507 cm³ four-cylinder engine, although the 3·2 litre engine introduced last year on the Pontiac Tempest indicated the revived interest of American designers in the large four. The Chevy II has an orthodox induction system. Its simple two port branch manifold feeds siamesed inlet ports on the left-hand side of the cylinder head. The tract is of flat, rectangular section, and there are sharp bends where the end branches leave the gallery. This manifold and the exhaust one are of cast iron, bolted together in the middle, in the usual manner; as is to be expected, there is a thermostatically controlled hot spot valve in the off-take of the exhaust manifold. A small



The Lagonda Rapide was the only British car exhibited equipped with the Continental type of suction operated compound horizontal carburettors. Its secondary throttle valves are actuated by suction diaphragms

Rochester single-barrel downdraught carburettor supplies the mixture and, surprisingly, features a hand-operated strangler valve instead of an automatic choke. A conventional type of shallow pan air filter fits directly on to the carburettor intake, and its silencing tube points forward.

Six-cylinder engines

Changes have been made in the carburation system of the Austin-Healey 3000 Mark II: in place of the previous carburettor arrangement, three S.U. semi-downdraught HS4 instruments are now fitted. This increased breathing capacity enables full advantage to be taken of the latest camshaft, which increases the lift of the inlet valves. Each carburettor is bolted to a short stub tract, in order to produce a slight ram effect. In turn, the induction stubs are bolted to the upper side of the exhaust manifold, thus providing excellent hot spots. This is a layout that could well be followed by others in installations of this nature; the resulting flexibility in city driving, particularly in winter, is well worth while. The three induction stubs are connected together by a long balance pipe, which lies above them, by the side of the rocker cover. To protect the carburettors from radiated heat, a large shield plate is fitted between them and the exhaust manifold. Separate pancake type air cleaners are fitted to the intakes.

Much interest was centred around the Jaguar E Type car. The three S.U. HD8 carburettors, with 2 in diameter throttle barrels, are mounted on the right-hand side of the cylinder head, but the arrangement differs from several others in that the carburettors are installed almost horizontally instead of with an appreciable downdraught angle: the inclination is about 5 deg. Each carburettor feeds an induction stub which branches into two short tracts, and therefore supplies two adjacent inlet ports in the cylinder head.

The two induction tracts of the central induction casting are symmetrically disposed, branching to front and rear from the carburettor flange, to feed cylinders 3 and 4. In contrast, the other two carburettors are each offset from the plane of symmetry of their respective ports, towards the transverse axis of the engine; consequently their tracts are of a rather peculiar shape. In the case of the front induction casting, the tract feeding cylinder 1 sweeps forward from the carburettor flange and then turns inward to the port. The tract feeding cylinder 2, however, bends rearward and then forward to meet its port. As would be expected, the rear casting, which supplies cylinders 5 and 6, is a mirror image of the front one. These unusual shapes are doubtless the result of much patient development work.

All three induction castings are jacketed for heating by the engine coolant, which is taken from a rail on top of the tracts. The three risers are connected by a balance pipe. Air for the carburettors passes through two tubes into a large cylindrical air cleaner mounted low down on the right-hand side of the engine compartment. Connecting the cleaner to the carburettor intakes is a plenum chamber of rounded triangular shape.

From the tank at the rear of the vehicle, fuel is supplied to the carburettor by a Lucas 2FP submerged fuel pump, mentioned earlier. The throttle control mechanism for a three-carburettor system is always something of a problem if a smooth and progressive action and freedom from engine torque reactions are to be obtained. Much thought has clearly been given to the arrangement employed on the E Type car, and the layout repays careful study. A long and well supported layshaft runs longitudinally above the carburettors; to prevent engine movement affecting the throttles, a lost-motion device links this shaft with the accelerator control on the engine bulkhead. From three levers on the layshaft, coupling rods extend downward to the levers on the throttle spindles. Here, however, there is an additional refinement: for each throttle there are two components—the throttle lever proper and a small pick-up lever. Since the coupling rods are connected to the pick-up levers, some further lost motion occurs on actuation of the throttle pedal, until the pick-up levers contact the main throttle levers and the throttles begin to open.

The carburation system on the new Jaguar Mark X saloon is almost identical with that of the E Type car, but the air cleaner arrangement is different. Connecting the intakes of the carburettors is a long air box of cast aluminium, which has an opening at the front. From this opening a length of trunking hose leads to the cylindrical air cleaner, which is mounted in a sealed chamber within the right-hand front wing. Air enters this chamber through two silencing tubes; the system is tuned for the greatest possible reduction of the intake noise. There are two fuel tanks, one installed at the back of each rear wing, and each contains a Lucas 2FP submerged fuel pump.

Another high-performance car, the Lagonda Rapide, has a very different carburation system on its 3,995 cm^3 engine, which is stated to produce 236 b.h.p. net at 5,000 r.p.m. Two Solex twin-barrel 44-PHH compound horizontal carburettors supply mixture to two separate three-port induction manifolds of cast aluminium. Each manifold has a gallery of circular section, with buffer ends. Both the end port branches curve inward to the cylinder head, whereas the centre one makes a right angle with the gallery.

One throttle barrel of the leading carburettor is situated

between the port branches of cylinders 1 and 2, and the other between those of cylinders 2 and 3; a similar layout has been used for the other carburettor and the remaining three cylinders. In this scheme, the front barrel of each carburettor is the primary one. To heat the mixture, engine coolant is fed through an orifice to each induction casting. A long air cleaner fits directly over the intakes of the carburettors, which are supplied by two S.U. electric fuel pumps mounted beneath the rear seat. These pumps draw their fuel from a common pipe linking the two fuel tanks, one of which is housed in each rear wing.

V-eight engines

On most of the American V-eight engines, the now-conventional layout of a four-barrel compound downdraught carburettor is employed. This instrument feeds a rather complicated induction system whereby one pair of throttle barrels supplies the two outer cylinders of one bank and the two inner cylinders on the other; the other two throttle barrels, of course, feed the remaining cylinders in a similar manner, and the tracts cross over and under each other within one casting. Usually, exhaust gas is employed to heat the mixture, control being effected by a thermostatically governed flap valve in the exhaust system.

The extremely fast, Bristol 407 is noteworthy for having a Chrysler 5,130 cm³ V-eight engine. Mixture is supplied by a Carter AFB 3131S four-barrel downdraught carburettor, the fuel for which is delivered by a Carter engine-driven mechanical pump. Surmounting and partly enveloping the carburettor is a large circular air filter, the silencing tube of which points forward.

Throttle control systems

For many years, the control systems between the accelerator pedal and the throttle lever on the carburettor have been the bane of the car designer. If rods are used, there is difficulty in arranging the linkage so that engine rock is not transmitted to the pedal, or to the throttle lever itself. This trouble can be eliminated by the use of a cable control, but unless the cable has a short and fairly straight run, and is lubricated regularly, the inner wire may tend to stick, with consequently jerky actuation.

The new Dunlop pneumatic throttle control has been designed to eliminate all these imperfections. Coupled to the throttle lever on the carburettor is a cylinder containing a spring-loaded rolling diaphragm. A plastics bellows unit, which is installed underneath the accelerator pedal is connected to the cylinder assembly by a length of plastics tubing. Pressure on the pedal transmits air pressure to the diaphragm at the carburettor, which opens the throttle.. It is claimed that this method of throttle control gives a very positive response and it certainly eliminates the complicated linkage so often employed.

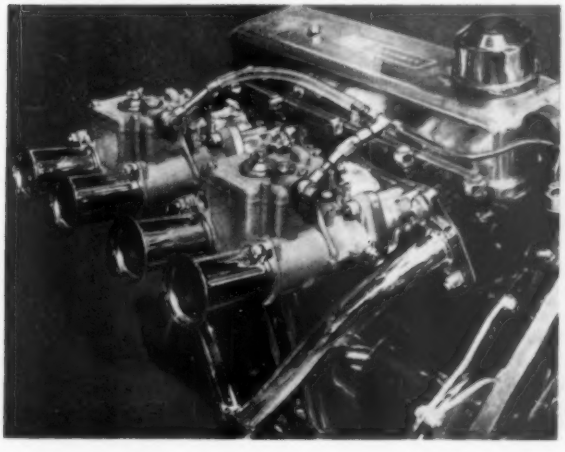
One of the most ingenious mechanical throttle-control systems seen at Earls Court is that employed by Saab on their well known three-cylinder two-stroke engine, which is fitted with a Zenith VN downdraught carburettor. Attached to the throttle spindle is the leading end of a nest of three plastics bellows, about 1½ in diameter. Mounted on the rear capsule of the nest is a torsion rod, which projects from the dash structure and is linked to the throttle pedal. Although the resulting assembly is torsionally rigid, an ample amount of universal movement is available, to accommodate the inevitable engine movement without transmitting it to the accelerator pedal.

Crankcase ventilation

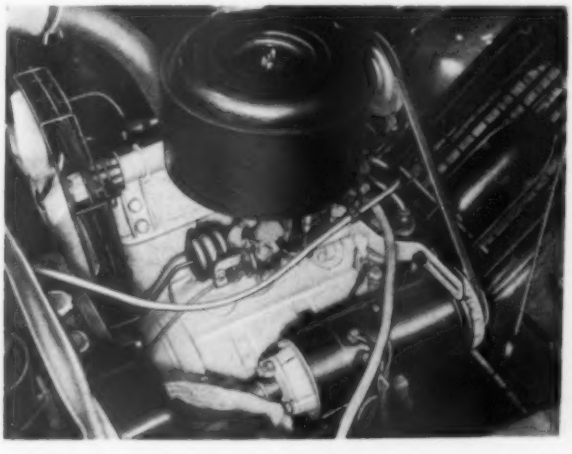
Another problem of the engine designer is that of evolving an efficient system of crankcase ventilation, to minimize condensation and the formation of sludge. The most common and easily applied method is that of connecting a tube from the rocker gear cover to the air silencer or filter; air is permitted to enter the crankcase system through a separate orifice. A few years ago, AC-Delco produced a venting device with which the induction depression is utilized to draw air through the crankcase into the inlet tract. Inserted in the pipeline of this device is a small spring-loaded conical valve, the characteristics of which are so arranged that the valve is wide open in the upper cruising and full-throttle range, when the depression is low, but closes at light throttle and idling, the depression then being high.

When the engine is working hard, and blow-by is likely to be most prevalent, the valve is open to its maximum amount. However, it is closed when the throttle is shut or only open a small amount, because blow-by is then less severe and the presence of a large air leak into the induction tract would introduce serious carburation difficulties. To ensure that there shall be some flow through the venting system in these conditions, the valve has a small hole, about 0·060 in diameter, which in some instances is reduced in size by the insertion of a split pin, to act as a jiggle-pin.

The Morgan Plus Four Super Sports model has the Lawrence-tuned version of the Triumph TR4 power unit, with two Weber twin-barrel horizontal carburettors on which are fitted fairly long air intake extensions



On the Saab three-cylinder two-stroke engine, an ingenious universal motion device, comprising a nest of plastics bellows, in the throttle control system accommodates movement of the engine on its mountings



CLUTCHES

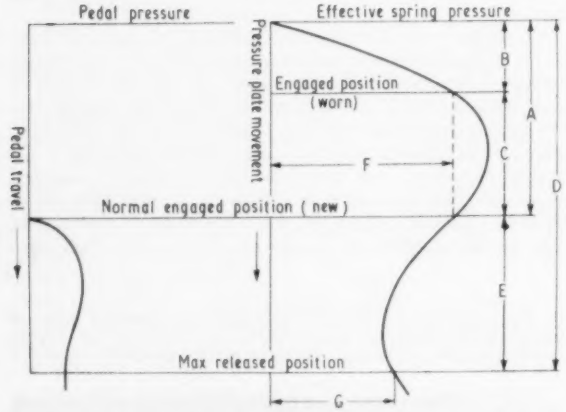
No Innovations Apart from the Fact That Several New Diaphragm Spring Type Units Have Now Been Introduced by the Component Manufacturers

IN the review of last year's Commercial Vehicle Exhibition, reference was made to the delightfully simple diaphragm spring type clutch exhibited by Laycock Engineering Ltd. This clutch, which was the first of its type to be introduced in Great Britain, has only seven components: these are the pressure plate, friction plate and diaphragm spring, a circlip, the clutch release ring, and the inner casing and outer cover. The diaphragm spring is located between the inner casing and the outer cover. Characteristically, this clutch maintains its original torque transmitting capacity throughout its normal life; in addition, it is smooth in action and does not suffer from the slip that can occur in other types owing to wear. The accompanying sectional view illustrates the simplicity of the basic design, and the performance characteristics are shown on a graph. This clutch, which is based on Häussermann patents, has proved very successful during this past season on various racing cars.

The Borg and Beck Co. Ltd, which supplies about 80 per cent of the clutches for the British automobile industry, as well as exporting in quantity, also manufactures two sizes of diaphragm spring clutch; in this design, the company's strap drive principle is incorporated. Three equally spaced, laminated straps are riveted to the cover plate, and their free ends are bolted to the pressure plate, thereby reducing parasitic internal friction. The straps also have to accommodate a small amount of axial movement of the pressure plate. Assuming that one or other of the two sizes of cover is acceptable for an installation, any size of clutch plate between 7½ in and 10 in can be accommodated.

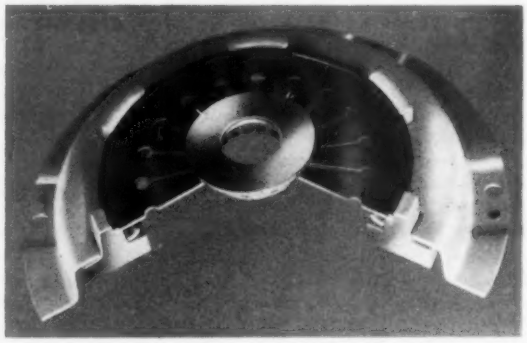
In some respects, the diaphragm spring type clutch offered by Newton and Bennett Ltd. has a marked similarity with that produced by the Borg and Beck Co. By and large, the differences concern the detail configuration, though there is a noteworthy one in respect of the straps, which are not laminated in the case of the Newton and Bennett design. The whole assembly is much simpler and lighter than the equivalent clutch of conventional layout.

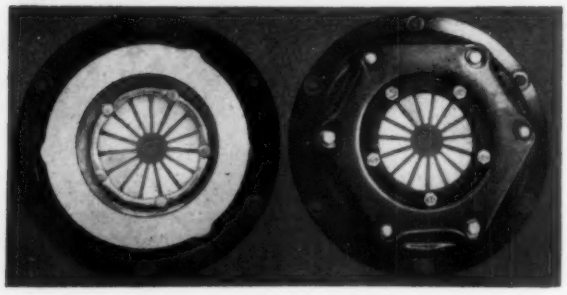
One of the most promising features of the diaphragm spring clutch is its basic suitability for high-speed applications, since all the main components are circular pressings



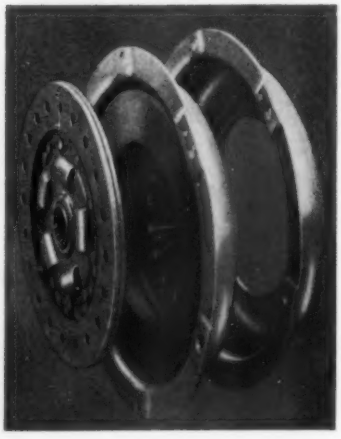
A *presser plate movement from free to normal engaged positions, with new driven plate;* **B** *with worn driven plate;* **C** *wear possible without loss of clamping load;* **D** *movement from free to released positions;* **E** *movement to effect release;* **F** *spring pressure when release begins;* **G** *spring pressure when release is complete*

Above: Laycock-Häussermann diaphragm type clutch characteristics

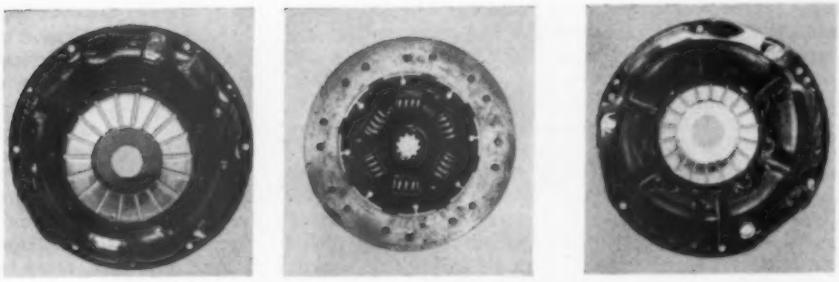




Above is a sectioned Laycock-Häussermann clutch and on the right is an illustration showing all of the components



Left: Two views of the Newton and Bennett strap drive diaphragm spring type of clutch assembly



Borg and Beck 8-8½ in and 9-9½ in diaphragm spring clutches can take 7-10 in diameter friction discs

or discs which are inherently easy to balance. The coil springs of the orthodox clutch tend to bend at the higher rotational speeds, thus reducing the effective pressure on the thrust plate and limiting the torque transmission capacity. It would, however, be entirely wrong to assume that the diaphragm spring clutch presents no problems. For instance, considerable knowledge and experience are required for the quantity production of the diaphragm springs, if they are to have consistent characteristics as well as being reliable over long periods.

On balance, though, the diaphragm spring clutch appears to be superior to the coil spring type. Consequently, it is rather strange that although diaphragm units have been well proved on the Continent and in America—besides being exhaustively tested in Britain—not a single British manufacturer has yet adopted them for a current production car.

Transmissions

There is Now Strong Emphasis on Automatic Systems, and an Increase in the Number of All-Synchromesh Gearboxes Installed in Vehicles

ALTHOUGH no British production car now features a crash type gearbox, a few manufacturers still supply boxes with unsynchronized engagement of first gear; most, however, have come into line with Continental practice in providing synchromesh on all forward ratios. In this country, the type of synchromesh with spring-loaded ball detents is the most widely used, but baulk ring, Porsche and ZF systems are becoming increasingly popular. The Porsche self-wrapping type synchromesh is, of course, a feature of some of the larger B.M.C. cars, and the excellent ZF mechanism, which incorporates baulking lozenges to prevent gear engagement before synchronization has taken place, has proved itself singularly successful on the Lotus Elite sports coupé. It is, therefore, of interest that a ZF gearbox is specified for the new Reliant Sabre sports car.

However, far more widespread and, indeed, fundamental developments are in progress in almost all the automobile manufacturing centres of the world, as is witnessed by the growing number and variety of automatic transmissions. In Britain, two new types have been made available during the past year, and these have lately been joined by the new and interesting Mercedes design which is standard equipment on the 300SE car and is optional for the 220, 220S and 220SE models.

In order to gain a true perspective of the current situation and, if possible, a glimpse into the future, a survey of automatic transmissions in general should be of value at this stage. The Hobbs Mecha-Matic and Smiths Easidrive transmissions are both in production; whereas the Easidrive is available as an optional extra on certain Rootes models, the Hobbs organization suffered a severe setback earlier this year when production ceased at Borgward, with whom an agreement had been signed not long before. Although the mode of operation and the design details of these two transmissions are radically different from each other, both are of the pure stepped-ratio type, incorporating what are sometimes called brain units that decide when the automatic shifts should be effected in all the different circumstances.

The G.M.C. Hydra-Matic 61-05 transmission is now offered by Vauxhall Motors Ltd. as an option for their Velox and Cresta cars. Daimler-Benz has evolved the rather similar Mercedes unit described later. Each design has a fluid coupling, a stepped-ratio transmission and a complex control system for the automatic gear changes. However, the G.M.C. unit has three speeds, as against the four of the Mercedes, and for this reason its fluid coupling embodies a torque multiplying element.

In the Borg-Warner transmissions, which, to most British and Continental motorists, are typical of the American trend, different principles are employed. It is, therefore, opportune to digress for a while to examine what effects different transmission systems might have on car performance in general. First, it can be appreciated that maximum engine power output is available in every gear on cars fitted with orthodox clutches and gearboxes. A similar power utilization factor would seem possible with the G.M.C. Hydra-Matic unit fitted to the Vauxhall cars. Any deviations from this ideal—that is, limited power utilization—are attributable to the sensing devices and control system that effects the actual gear changes. The new Mercedes gearbox, though, seems to have been designed to use the full power, or at least most of it; consequently, this transmission is unusually flexible in terms of its response to widely varying driving techniques.

The Borg-Warner Model 35 transmission is basically different from those just mentioned, in that there are two different stages of power utilization. One stage, perhaps the most important, is the power utilization during the conversion phase, that is, while the output torque of the converter is greater than the input or engine torque; the other is, of course, the power available when the converter functions merely as a hydraulic coupling. According to published data, the Model 35 can utilize the full engine power up to engine speeds of only about 1,700 to 1,800 r.p.m. At

higher speeds, the output torque is simply the engine torque multiplied by the appropriate mechanical gear ratio. Moreover, the control system limits this power utilization according to the road speed and throttle position, thus safeguarding the engine and transmission.

This aspect of the characteristics of a transmission system will become of increasing importance as more and more automatic units come on to the market, and in particular because it is known that the leading American, British and Continental vehicle manufacturers are experimenting intensively with various types of fully hydrostatic or differential hydrostatic transmissions. Probably the best known applications of hydrostatics to automobile transmissions are J. G. Giles' design (which is under development at M.I.R.A.) and the Italian Badalini system. Most other developments are taking place behind locked doors. Characteristically, hydrostatic transmissions are capable of dealing with a constant power input, and thus provide an ideal hyperbola of tractive effort, which must be limited if the stresses in final drives, and in the components of hydraulic motors, are not to exceed permissible levels. In certain applications, it is probable that tyre adhesion sets a natural limit on excessive traction and consequently high stresses.

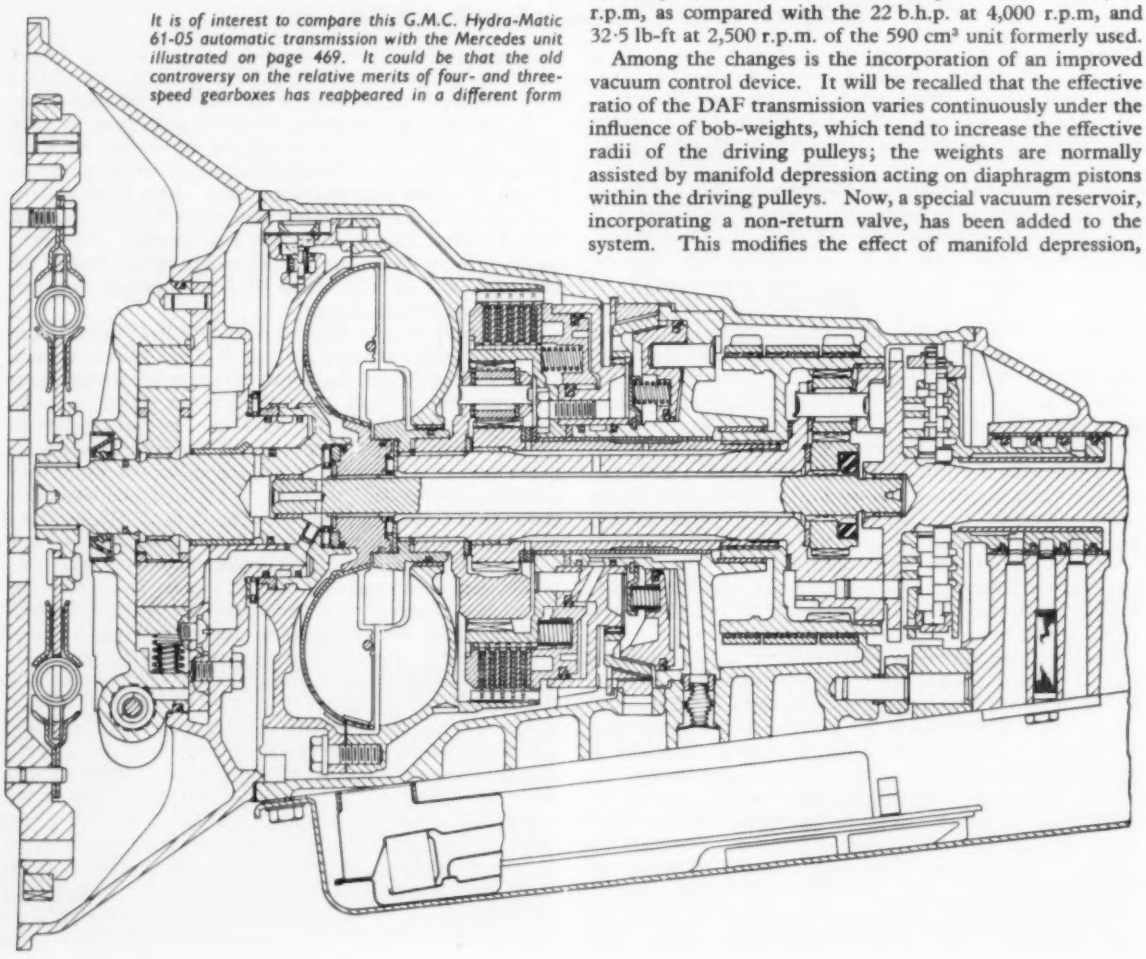
It has often been assumed that hydrostatic transmissions are likely to do away with all forms of gearing, as the hydraulic motors can be mounted at the driving wheels. Even if one ignores the requirements of minimal unsprung weight—impossible to achieve with necessarily heavy hydraulic motors—a study of the fundamentals, as currently understood, suggests that this belief is ill founded. For instance, if a pressure of 500 lb/in² is required to provide direct drive—that is, no torque multiplication between the engine and the driving wheels—and the maximum permissible working pressure is 3,500 lb/in², the greatest reduction available is only 7 : 1, whereas an overall low gear reduction as great as 20 : 1 may be necessary.

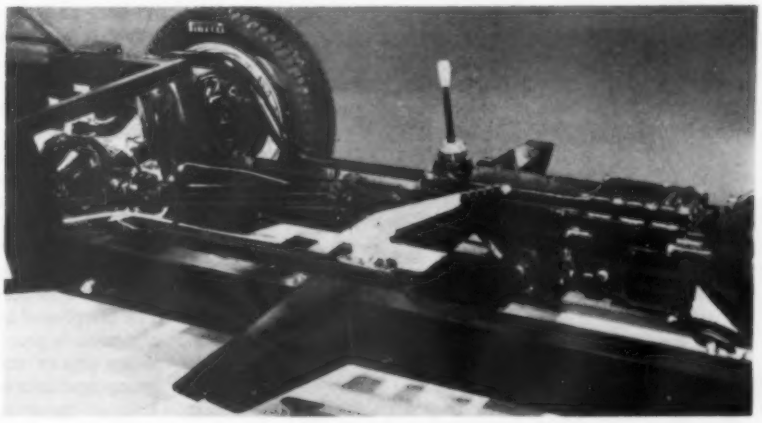
Moreover, few, if any, variable-displacement pumps of adequate capacity are capable of being run at up to 5,000 or even 6,000 r.p.m, as many modern automobile engines are doing. Apart from this, it would not be easy to manufacture, in large quantities, cheap hydraulic pumps and motors that would operate efficiently at these pressures without producing the irritating and distinctive noises so characteristic of many a high-pressure hydrostatic system. For these reasons, it does not seem presumptuous to suggest that the early introduction of hydrostatic transmission on popular cars is unlikely, even if ways and means are found to overcome the cost and weight problems. Indeed, contrary to certain published views, some time must elapse before hydrostatic systems constitute a challenge to other forms of automatic transmissions on motor vehicles.

The odd man out among current types of automatic drives is still the very ingenious, and by now well proved, Variomatic belt drive system fitted to the Dutch DAF car, which is now available in Great Britain. This transmission has not only been improved, in the light of service experience, but has also been modified to suit the larger, 746 cm³ engine now employed. This new engine develops 30 b.h.p. at 4,000 r.p.m, and has a maximum torque of 42 lb-ft at 2,800 r.p.m, as compared with the 22 b.h.p. at 4,000 r.p.m, and 32·5 lb-ft at 2,500 r.p.m. of the 590 cm³ unit formerly used.

Among the changes is the incorporation of an improved vacuum control device. It will be recalled that the effective ratio of the DAF transmission varies continuously under the influence of bob-weights, which tend to increase the effective radii of the driving pulleys; the weights are normally assisted by manifold depression acting on diaphragm pistons within the driving pulleys. Now, a special vacuum reservoir, incorporating a non-return valve, has been added to the system. This modifies the effect of manifold depression,

It is of interest to compare this G.M.C. Hydra-Matic 61-05 automatic transmission with the Mercedes unit illustrated on page 469. It could be that the old controversy on the relative merits of four- and three-speed gearboxes has reappeared in a different form





The ZF fully-synchronized four-speed transmission has been adopted for the Reliant Sabre sports car. The synchronizing mechanisms in this box have baulking lozenges to prevent engagement of the gears before the synchronization has been completed

and has a twofold effect upon the performance of the car:

(a) Assuming a constant rolling resistance, a small increase in the throttle opening no longer tends towards a lowering of the ratio, because the reserve vacuum initiates an opposing effect towards a higher ratio; consequently, the car accelerates according to the rising engine speed and power output;

(b) When the throttle pedal is fully depressed, the lowest ratio for the particular road speed is immediately adopted, to provide maximum acceleration.

The effect of the kick-down action is to cut off the vacuum assistance of the bob-weights. Consequently, the pulley flanges move apart and so reduce the radius, and therefore the gear ratio. There is no doubt that the combination of the more powerful engine and the improved transmission will greatly enhance the road performance of these cars. One of the more interesting characteristics of the Variomatic transmission is that the full-throttle tractive effort and power-available curves would, within limits and reservations, be similar to those obtainable with hydrostatic transmissions.

The latest addition to automatic drives is, of course, the Borg-Warner Model 35 transmission, which was designed and developed for the very popular 1½ litre class of car, and was described in the October and November issues of *Automobile Engineer*. It has been carefully developed and extensively tested by various manufacturers in Britain and abroad, and is available as an optional extra on the new Austin A.60, Morris Oxford Series VI, Wolseley 16/60, M.G. Magnette and Riley 4/72 models, besides being available for other cars.

In contrast to the DG unit, the Model 35 does not feature a lock-out clutch for the torque converter, and the two planetary gear trains are replaced by a single, compound epicyclic gear set, which provides three forward ratios and reverse. These ratios are engaged by means of two multi-plate clutches and two band brakes. The absence of a lock-out clutch means, of course, that the three-element converter is in continuous use. There are alternative sizes of converter, of 9½ and 11 in diameter, to facilitate the matching of engine to transmission performances.

Pistons, coaxial with the clutches, engage them as required, and the band brakes are actuated by servo pistons and toggle levers. Two hydraulic pumps are employed, a feature that permits tow- or push-starting, and the careful design of the control system ensures smooth changes. Whereas, with the DG transmission, the holding position for engine braking is available only in low gear, both the intermediate and low gears of the Model 35 can be held. It is worthy of note that the transmission is filled for life by the factory, in conformity with the present trend towards the elimination of routine servicing. For some applications, however, the selection of a suitable fluid must have presented considerable difficulty.

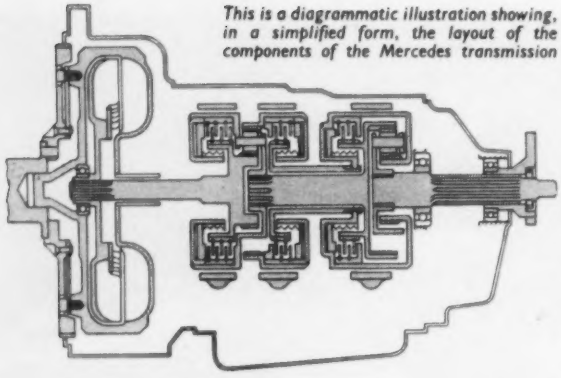
At last year's London Show, a focus of attention was the G.M.C. Hydra-Matic 61-05 transmission, which has since proved itself in numerous Vauxhall Velox and Cresta cars. This unit was described in detail in the December 1960 and January 1961 issues of *Automobile Engineer*. However, in view of the importance of the Hydra-Matic and new Daimler-Benz transmissions, sectional drawings of both units are reproduced, and their salient features are covered in the ensuing paragraphs.

Of all the automatic transmission systems in current use throughout the world, the Hydra-Matic series has the longest history. The 61–05 model was evolved in the light of experience gained with the larger four-speed G.M.C. units. It conforms to the general Hydra-Matic principles, in that it is a stepped-ratio transmission incorporating a hydraulic coupling, but beyond this and in detail the similarity with the larger types ends abruptly. First, the 61-05 has only three forward ratios, and the coupling has been developed by the embodiment of a torque multiplying element, the function of which is identical with that of a reaction member, or stator, in any conventional three-element torque-converter. In this way a small torque multiplication is obtained in low gear and reverse, but the coupling is effective at all times.

The main driving components of the Hydra-Matic 61-05 are the hydrokinetic coupling—which is driven by a resilient member on the engine—and two simple epicyclic gear trains; the latter are either compounded or separately engaged by a multi-plate clutch or by a band brake and a cone clutch. The last-mentioned assembly serves to anchor the annulus of the front gear train to the casing when reverse is required. By far the most intricate portion of the unit is the hydraulic control system, which determines when gear changes are to be made, and energizes the clutches and brake. The actual sequence of operations and the details of the control system were fully covered in the article mentioned earlier.

Although the hydraulic controls are indisputably complex, they work most reliably, and effect the gear changes very smoothly. Furthermore, engine braking is available over a substantial range of second gear performance, when the selector lever is in the S position; when L, the low gear hold position, is selected, the engine braking provided is practically as effective as in the lower gears of manual shift transmissions. It is evident that, because of its complexity, this excellent transmission can be produced economically only if the quantities justify the adoption of the very latest manufacturing techniques.

As previously stated, the German Daimler-Benz company has developed its own automatic transmission system, which is based on the belief that a transmission of this

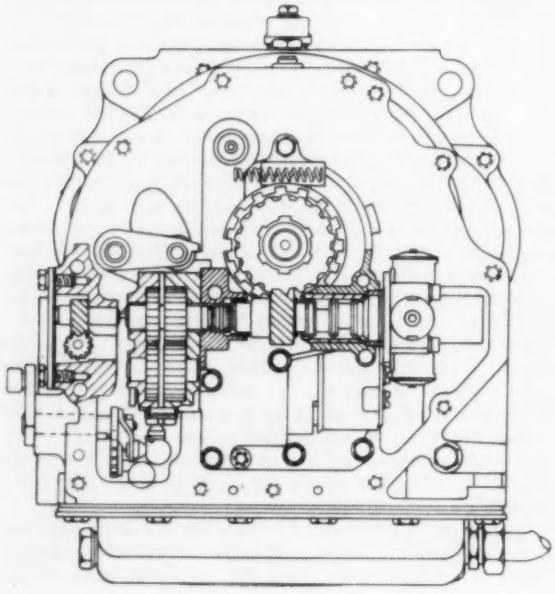


This is a diagrammatic illustration showing, in a simplified form, the layout of the components of the Mercedes transmission

type influences the character of a car's performance much more than does a manual shift transmission. The degree of power utilization and the choice of gear change points, as well as the overriding controls, have a marked bearing on the liveliness and general performance of the vehicle. In Europe, too, the attitude towards automatic gear changing is quite different from that in the U.S.A, because the economic aspects of motoring have a greater significance. Considerations related to taxation and running costs have caused emphasis to be placed on smaller engines, and this means that a higher percentage, or even all, of the engine's power output must be made available in the lower gears. Moreover, European conditions have caused many motorists to develop highly individual driving techniques, which enable them to obtain remarkable performances from cars with orthodox transmission systems. Probably as a result of this, a widespread belief has grown up that automatic transmissions on European cars must give the driver a far larger measure of driver control than is the case in America. Finally, the weight of the transmission must bear a sensible relationship to that of the car.

Although the general layout of the new Daimler-Benz transmission follows established American practice, there are considerable differences. In the first place, to ensure smoothness, a cush-drive assembly is interposed between the flywheel and the fluid coupling; it resembles that of an orthodox single-dry-plate clutch. Two simple planetary gear trains provide four forward ratios and reverse.

The cross-section of the Mercedes automatic transmission



The runner shaft of the coupling drives the sun gear of the leading train; this gear can be locked by a multi-plate clutch to the planet carrier, which is permanently connected to the annulus of the rear gear train. Two more multi-plate clutches and three band brakes act on the various elements of the gear trains to provide the different ratios. It is claimed that the design of the band brakes is such that they will not require adjustment throughout the life of the transmission. The gear shifts occur in response to hydraulic signals proportional to the throttle position and road speed; they are phased as power-shifts, so that the power utilization factor is high. Moreover, in line with the underlying philosophy of the design, a considerable measure of overriding manual control has been incorporated.

At all times, the hydraulic coupling between the engine and the gearbox remains effective. It has a special configuration ensuring low drag at high percentage slip—for example, when starting from rest—when it has the performance characteristics of a smaller-diameter unit. At high speed, however, over the primary performance range when the slip is small, the characteristics become those of a larger coupling. This unusual performance is ascribed to the shortness of the sections of the impeller and the runner at the major effective diameter; these sections abruptly change the direction of fluid flow from predominantly radial to axial. It would appear that the price of this very desirable feature is the necessity of incorporating a heat exchanger for the fluid.

The hydraulic system comprises two oil pumps, a centrifugal type governor and the usual group of hydraulic valves and actuators. A parking lock of conventional type is incorporated. Although the limited space available here precludes a detailed description of the construction and functioning of the transmission, a summary of these is desirable, to illustrate the methods adopted by the Daimler-Benz engineers in achieving their aims.

The front gear train is capable of providing three different gear ratios, 2·52 : 1 and 1 : 1 in the forward direction and 1·52 : 1 in the reverse direction. Similarly, the rear train is also capable of producing three different gear ratios. In first gear, the reduction is $2{\cdot}52 \times 1{\cdot}58$, or 3·98 : 1. It is obtained by energizing two of the band brakes to stop the annulus gear of the front train and the sun gear of the rear train. The power flow is from the hydraulic coupling to the front sun gear, and then by way of the front planet carrier to the rear annulus and planet carrier, which drives the output shaft.

For the second gear ratio, of 2·52 : 1, only the front gear train is in action. As before, the power flow is from the coupling to the front sun gear but, from the front planet carrier, it goes directly to the output shaft, since the rear clutch locks the rear sun and annulus gears together to prevent any relative rotation. The band brake that held the front annulus stationary for first gear is, of course, again on.

In third gear, the reduction of 1·58 : 1 is provided entirely by the rear gear train. One of the multi-plate clutches locks the front sun gear and annulus together, thus preventing relative rotation. Again the rearmost band brake is applied, to stop the rear sun gear; the power flow is from the coupling, through the locked front gear train to the annulus of the rear train, the plant carrier of which drives the output shaft.

The top gear ratio of 1 : 1 is obtained by locking together the front annulus, the rear annulus and the rear sun gear: this is effected by engagement of the appropriate clutches. The reverse ratio of $1{\cdot}52 \times 2{\cdot}72$, or 4·13 : 1, is obtained by applying the remaining, and so-far unused band brake—which stops the front planet carrier, together with the rear annulus—and the clutch that is employed for second gear.

Consequently, the power flow is from the coupling to the sun gear of the front train which, since the planet carrier is stationary, causes the annulus to turn in the opposite direction; from the annulus, the drive is taken through the clutch to the rear sun gear, and the rear planet carrier drives the output shaft, as in the other ratios.

From the foregoing it is clear that the gear trains are compounded only when first or reverse is required; for the second and third ratios only one gear set is in use—the other merely rotating as a unit—while for fourth gear neither train is operative. In this manner, a high overall transmission efficiency has been obtained, and the noise level in the most widely used ratios has been minimized. Moreover, the arrangement ensures that neither forward clutch has to deal with more than engine torque, while the torque transmitted by the forward bands is limited to $1\frac{1}{2}$ times that of the engine. Smooth engagement of the clutches is obtained by causing the manifold depression to control the oil pressure applied.

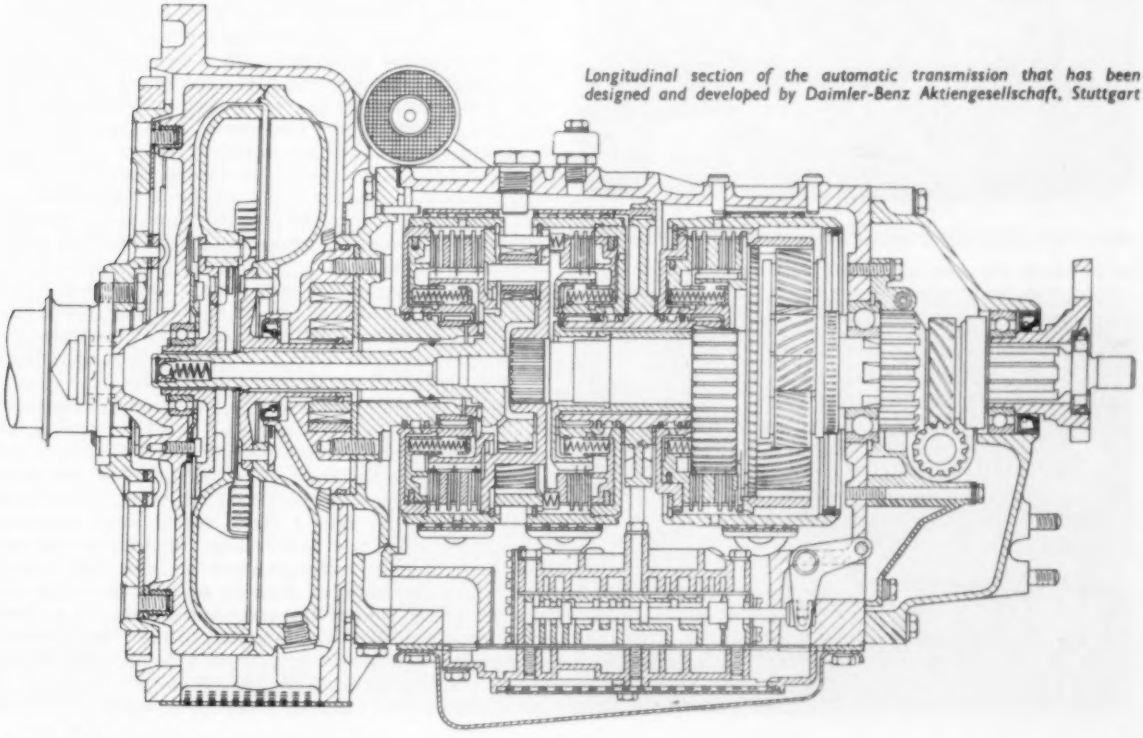
It is noteworthy that, for the purpose of selecting the automatic gear shifting points, the speed range of the vehicle has been divided into zones, so the choice is always only the next higher or the next lower gear than that in use. The design aim was at ensuring that automatic shifts should take place only when the required performance could be more readily and economically obtained in the succeeding gear ratio, and that the actual shift points should depend primarily on the permissible maximum engine speed, but indirectly on the permissible noise level. Accordingly, the up-shift point in each gear should lie upon the full-throttle power curve for the next higher gear. It was found that the best basis for up-shifts was a predetermined intake manifold depression. The down-shift points, however, occur independently of the throttle position, at fixed road speeds. The governor, which is supplied with oil by a separate small pump, determines the various speed zones, each of which corresponds to a specific oil pressure.

Once the desired cruising gear has been engaged, no downward change will take place unless the speed falls drastically; merely increasing the throttle opening does not induce a shift. This feature is most desirable, since unexpected down-shifts can cause skidding on wet or icy roads, and fuel consumption is reduced by eliminating unnecessary changes to a lower ratio. Nevertheless, a kick-down change into the next lower gear, for the purpose of accelerating, is always possible provided the road speed is below the permissible maximum for that gear.

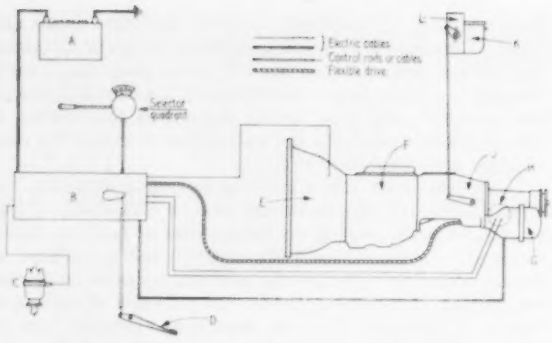
Creep has been minimized by arranging that the car always comes to rest in second gear, a kick-down of the accelerator pedal causing the engagement of first gear when required. Generally speaking, creep is not a problem at normal operating temperatures, but since it can be embarrassing during the warm-up period, the principle of coming to rest in second gear must be considered a sensible one to adopt. Although it becomes an almost reflex action to use the kick-down whenever more rapid acceleration is needed, the driver has the additional choice of manually overruling the automatic control by using the selector lever.

Of the six positions for the selector lever, three provide forward speed ranges. These six positions have the successive designations P, R, O, 4, 3 and 2. The first is, of course, the parking position, in which a pawl engages with a gear on the output shaft, to prevent the rear wheels from turning. If the R position for reverse is selected while the car is in forward motion, actual engagement of the ratio cannot occur until the road speed falls below 6 m.p.h. A safety feature, to prevent engagement of the pawl when the vehicle is in motion, is also operative in the P position. The O position is, of course, neutral, when no power flows through the transmission. An interlock system ensures that the engine can be started only when O or P has been selected.

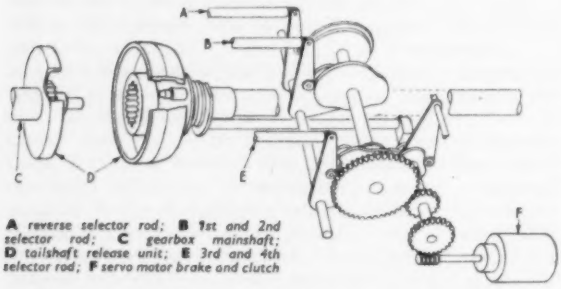
For normal driving in traffic or on the open road, the lever is set at position 4. All four forward ratios are then selected automatically, or at the driver's discretion, as previously explained. In mountainous country, the lever is set at position 3, to give what is called the climbing range, in which automatic upward changes beyond third gear will not occur. This range is also useful for long descents, because of the effective degree of engine braking obtained. If



Longitudinal section of the automatic transmission that has been designed and developed by Daimler-Benz Aktiengesellschaft, Stuttgart

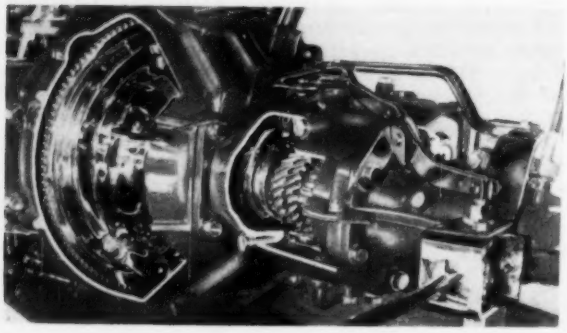


A battery; **B** control unit; **C** distributor; **D** accelerator pedal; **E** coupling, and overrun switch; **F** gearbox; **G** actuator servo motor; **H** governor generator; **J** actuator; **K** carburettor; **L** override throttle control



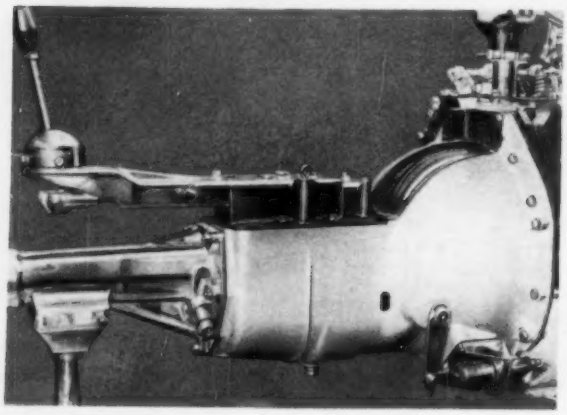
A reverse selector rod; **B** 1st and 2nd selector rod; **C** gearbox mainshaft; **D** tailshaft release unit; **E** 3rd and 4th selector rod; **F** servo motor brake and clutch

The two diagrams above are of the new Smiths transmission system



Above: The complex control linkage on the Vauxhall VX 4/90 gearbox

Below: Daimler four-speed synchromesh gearbox on the V-eight engine



position 2 is selected, automatic changing is limited to first and second gear only. This low range is intended primarily for use when towing a caravan over mountain passes, or where gradients or other conditions demand extra engine braking. First gear is available for part-throttle performance at road speeds not exceeding 25 m.p.h.

Having complete confidence in their engines, and being well aware of the liking of many Mercedes drivers for the more sporting motoring technique, Daimler-Benz have dispensed with any limitations on the engine performance when either 3 or 2 is selected. The full range of engine speed and power is, therefore, available when automaticity is restrained to either of these two ranges.

It is of interest to compare the new Daimler-Benz transmission with the Hydra-Matic 61-05 unit previously described. These two transmissions were created for quite different classes of car, and therefore the problems have been solved in different ways. If comparative evaluations were more acceptable, we might find that the old subject of controversy—four-speed gearboxes *versus* the three-speed type common in America—has reappeared in a new form. In any event, students of transmission design will find much food for thought in these two very advanced systems.

At the time of the London Show, Smiths Motor Accessories Ltd. had available a number of demonstration cars equipped with prototype automatic transmissions of an entirely new conception. These units are related to neither the earlier Easidrive type, nor to the Hobbs Mecha-Matic nor any of the hydrokinetic transmissions. Of equal interest, perhaps, to the actual design is the underlying philosophy, which is based upon the belief that an automatic transmission for the more popular sizes of European cars ought to comply with a few simple rules:

1. The additional cost to the purchaser should not be more than 10 per cent of that of the car to which it is fitted;
2. For all normal driving, conscious gear shifting ought to be eliminated;
3. The transmission should provide a performance that compares favourably with the best that a skilled driver can obtain with an orthodox manually controlled unit.

The new Smiths single-coupling automatic transmission was designed and developed with these points in mind. Furthermore, it was assumed, with some measure of justification, that existing forms of automatic transmission are relatively expensive by comparison with the manually controlled systems they are meant to replace. This high cost is due to the fact that the automatic types have never been required in numbers adequate for the installation of costly transfer machines and other advanced aids to modern quantity production. Consequently, if the proposed transmission could embody a substantial proportion of the orthodox transmission, the magnitude of the problem would be reduced. In addition, the car manufacturer could continue to select the gear ratios he regarded as most suitable, besides producing the gears as at present, thus simplifying servicing procedure and the problem of spares.

Each of the prototype transmissions therefore comprised the following units: one magnetic powder coupling, in place of the normal friction clutch; a standard synchromesh or constant-mesh gearbox; a special gearbox extension housing containing a dog clutch unit together with a baulk type synchronizing unit, a small electric servo motor to operate the cam type gear change mechanism, and an alternating current tacho-generator to give road speed signals to the governor; an electrical actuator switching unit attached to the side of the extension housing, to receive, from the control unit signals passed to it by the governor and/or the driver and to interpret them for the servo motor; the control unit itself, which, for convenience in respect of the layout of the throttle linkage and selector quadrant

connections, is preferably mounted beneath the facia and contains the transistorized take-off control and governor, the selector switch and other electrical equipment; a selector quadrant having neutral, drive, reverse and hold positions; a throttle override control, consisting of a small reversible electric motor and a simple linkage to the butterfly.

As this is, in many respects, an unusual type of automatic transmission, it is necessary to explain the purpose and functions of the individual units. The magnetic powder coupling transmits the engine torque to the gearbox. Attached to it is an over-run switch, which interrupts the main current supply to the coupling when it runs faster than the engine, though a small current is still supplied through a resistance. Because of the reduced excitation, a smooth pick-up is assured after gear shifts. Although a standard gearbox is used, the third-motion shaft and the selector rods are modified to accommodate the master synchronizing unit and the gearshift mechanism respectively.

The gearshift mechanism consists of three bell-crank levers, which are linked to the selector rods at one end and are actuated by cams that rotate whenever the servo motor is appropriately energized. These cams provide positive lever movement in each direction, and in addition there is a lost-motion device for the first gear and reverse selector; this device becomes effective should the coupling teeth meet face to face and fail to engage. In this case, the engagement is completed by spring pressure as soon as sufficient relative rotation of the teeth has occurred.

On standard transmissions, the third-motion shaft is nowadays extended so that the propeller shaft, and with it the floor tunnel, can be low. In the new Smiths transmission the third-motion shaft and tailshaft are separate; they are connected by a sliding dog, baulk type synchromesh device, which has been designed to withstand the first gear synchronizing torque. This synchromesh device is moved in and out of engagement by a pair of actuator cams. It functions in a similar manner to the usual type of synchromesh, although the initial force on the cones is applied by a spring detent. During this phase the cone rotates slightly relative to the tailshaft; consequently, the baulking pins are brought into contact with the cone, and considerable synchronizing torque is thus made available. In fact, it has been found necessary to introduce spring elements, in the form of Belleville washers, between the synchronizing cone and the operating linkage, to prevent too high a synchronizing torque due to self-servo effect. Without these springs, the transmission could be subjected to considerable shock loading.

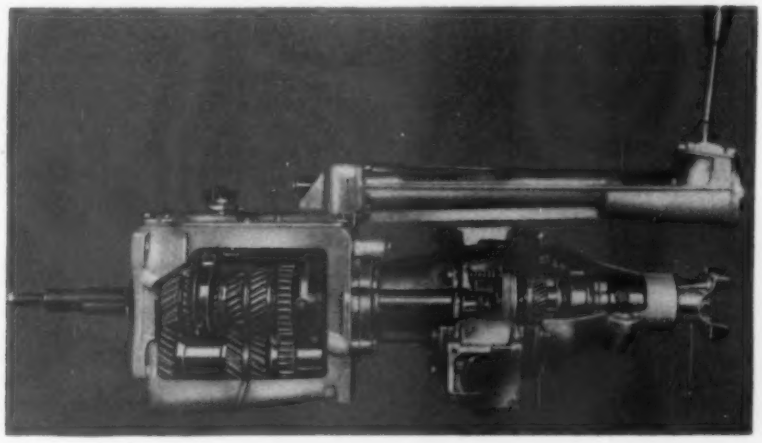
The power for all gear changes is provided by a small 12V d.c. reversible motor, which is mounted in a waterproof casing on the gearbox extension. The only unusual feature of the motor is that it carries an electromagnetically controlled brake and clutch unit. Spring pressure is used for application of the brake, which is released electromagnetically. The clutch is engaged simultaneously with the release of the brake, whenever the motor is energized for a gear change. It should be noted that the brake stops and holds the actuator accurately in the appropriate position, and the interaction of it and the clutch relieves the gearchange mechanism of the inertia effects of the motor at the completion of each shift.

Inevitably, the electrical and transistorized control system is relatively complex, but it has been developed against the background of Smiths vast experience in the field of instrumentation and of the Easidrive transmission. As mentioned previously, the system includes a small governor generator, switches and relays, in addition to the selector quadrant and lever, and the connections to the throttle lever and engine ignition distributor. All gear changes are initiated by the governor and the signals are modulated in relation to the road speed and the driver's wishes; the selection of neutral causes the powder coupling to be de-energized and first gear to be engaged.

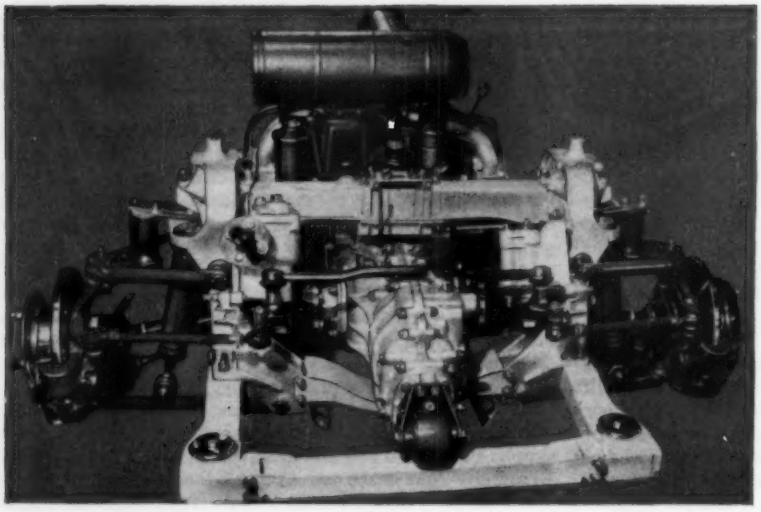
In view of the complexity of the control system, some clarification of the operational sequence is desirable. For simplicity, upward and downward changes will be dealt with separately. The initial assumption is that the car is travelling in first gear and the system has sensed that a change into second gear is required. First, the powder coupling is de-energized and the throttle closed to keep the engine under control. The actuator then isolates the gearbox from the final drive, by disengaging the dog clutch of the master synchromesh unit in the gearbox extension; having done this, it moves further, to disengage first gear and engage second gear. In this phase, the rotation of the gears within the box is synchronized by the powerful synchromesh in the extension housing, before the sliding dog coupling re-establishes the mechanical connection between the third-motion shaft and the output shaft. In re-establishing this connection, the actuator switch rotates to re-energize the powder coupling, and simultaneously releases the throttle override control. The circuit is then ready for the next signal, to make another upward change or a downward one, as required.

In the case of a downward change, this sequence of events is repeated, except that the actuator motor is rotating in the opposite direction, and the throttle is only partially closed. Smooth re-engagement of the powder coupling after a change is obtained by the action of the over-run switch, which delays full re-energization as long as the speed of the driven member of the coupling exceeds that of the engine. This safeguard against rough and jerky re-engagement is effective during all downward changes, regardless of the throttle position at which they take place.

When driving a car fitted with one of these prototype transmissions, the author of this review had a feeling of instant familiarity, and found himself prepared to tackle



The Volvo four-speed synchromesh gearbox and Laycock-de Normanville overdrive sectioned to disclose the robust and simple form of the mechanism. The control extension enables a short gear lever to be used



For accessibility, the engine of the front-wheel-drive Lancia Flavia is mounted in front of the differential housing, and the gearbox is situated immediately behind both

Below: Another front-wheel drive transmission assembly is that of the Auto-Union DKW. The gearbox is completely assembled before the cover is secured in place

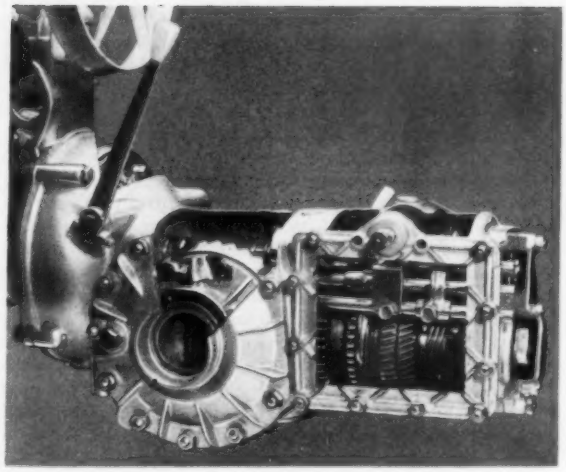
heavy city traffic or open main road driving without the slightest hesitation. Although the changes at light throttle seemed a little more noticeable than when a more vigorous and determined manner of driving was adopted, this impression was probably attributable mainly to excessive diligence in searching for possible limitations. The only other point worthy of criticism is that starting by pushing or towing is possible only if the battery is capable of energizing the powder coupling. A holding position is, of course, provided to enhance the engine braking when the car is descending long gradients. In general, the transmission does not seem to possess any really significant shortcomings.

A virtue of the Smiths single-coupling automatic transmission is that it can be applied to any multi-ratio synchromesh gearbox. Moreover, the gear changes will be smoother than with manual control, almost irrespective of the efficiency of the normal synchromesh in the gearbox: this is because the isolation of the gearbox during a gear change reduces the demands made upon that synchromesh; a similar, smooth-change characteristic is often experienced on cars fitted with synchromesh gearboxes and a freewheel. In theory at least, it seems feasible that the automatic change principle could equally well be applied to a constant-mesh gearbox without synchromesh. However, practical considerations suggest that the device is best for synchromesh systems.

It would be wrong to leave the subject of automobile transmissions without recording the sad fact that, after more than 30 years of admirable service, the delightful combination of a fluid flywheel and a planetary, preselector gearbox is no longer to be available on Daimler cars. Since this demise is due to the high standard of modern automatic transmissions, and to progress made with synchromesh gearboxes, it is gratifying to consider that this Daimler transmission was the ancestor of many automatic systems.

As stated earlier, fully synchronized gearboxes are gaining ground. This type of unit is now embodied in cars in almost every size and price category, among them NSU Prinz models, Mercedes, Volkswagen and Vauxhall, as well as DKW, Volvo, Peugeot and the new Reliant Sabre car.

The front-wheel drive and transmission unit of the DKW range of cars has perhaps a longer history than any other of its type. Consequently, it is not surprising that the unit is particularly neat and is extremely reliable in service. Volvo cars have made their mark on the international sporting scene, owing to their consistent success in rallies all over the world. The current models are undoubtedly very well built; this quality is well revealed in the compact and simple



all-synchromesh gearbox, which has been skilfully mated to the British Laycock-de Normanville D type overdrive unit. To comply with the requirements of sporting drivers for rapid and precise gear changing, a short and sturdy floor mounted gear lever of the semi-remote type is employed.

During recent years, there have been numerous cases of conversion from a direct gear change mechanism to a remote system with a lever on the steering column. Lately, the reverse trend has been more common: an example of it, to judge by the external linkages, is the four-speed, all-synchromesh gearbox on the Vauxhall VX 4/90 and—as an optional extra—on the Victor. So long as the conversion is reliable and effective, the motorist is unconcerned, but the engineer might well wonder at the economics of this expedient, for he is often confronted by limitations allegedly imposed by economic considerations.

In keeping with Lancia traditions, the gearbox and differential unit for the front-wheel drive of the new Lancia Flavia is a fine piece of engineering. The light alloy casing is well ribbed for rigidity and is split in the plane through the axes of the shafts; all four forward ratios of the all-indirect gearbox have synchromesh engagement. For accessibility, the engine is situated in front of the final-drive housing, behind which is mounted the gearbox assembly.

Propeller Shafts and Final Drives

Growing Interest in Constant-Velocity Joints and Recirculating Ball or Roller Type Splined Couplings

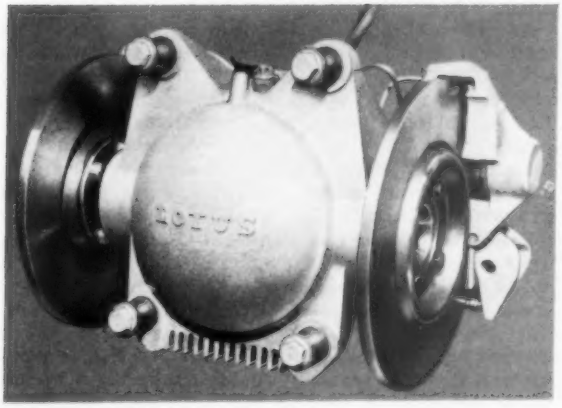
THERE was little new to be learned regarding propeller shafts at Earls Court. The most significant feature was the virtual absence of devices for introducing sufficient torsional flexibility into the drive line to absorb jerks and shock loads. Transmission shocks often become audible to an objectionable extent, particularly in the case of vehicles with independent suspension, which requires a relatively solid mounting of the final-drive unit. However, the absence of high-amplitude flexible couplings actually in drive lines does not mean their demise, for extensive experimental and development work—in respect of which publicity is not yet appropriate—is being carried out.

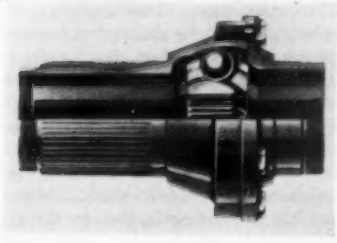
Other matters that are receiving attention on both sides of the Atlantic are related to constant-velocity joints and recirculating-ball or roller type propeller shaft splines. Daimler-Benz were, of course, the first to introduce—on their low-pivot swing-axle arrangement—the recirculating-ball type of splined shaft. The propeller shaft of the 1961 Lincoln Continental incorporates recirculating needle roller splines and a torsionally flexible coupling to obviate resonance in the drive line. In addition, a double Hookes type joint is used in order to avoid shaft oscillations, and consequent vibration, during large angular displacements.

In the front-wheel-drive system of the Lancia Flavia, the latter problem is solved by employing two Birfield constant-velocity joints for each final-drive shaft. The inner joint is housed in a pot, and slides axially on balls, to provide length variation with suspension movement, while minimizing the friction thrust on the inboard bearings. These Birfield joints are, of course, manufactured in large quantities for the B.M.C. ADO 15, on which each half-shaft has a flexible Hookes type joint at its inboard end and a Birfield constant-velocity joint at the other.

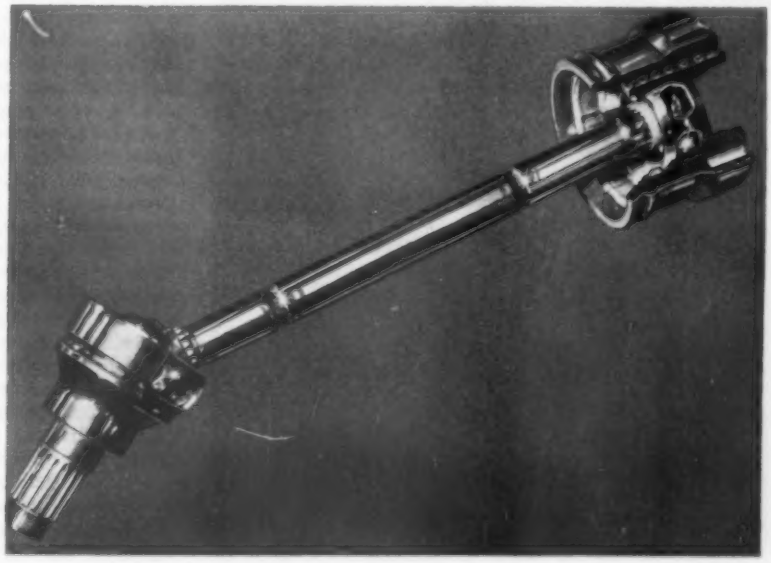
Independent rear suspension is still all too rare, but Jaguars have joined the select band with their new E type sports car and Mark X saloon. In both instances, a standard Salisbury hypoid final-drive unit is housed in a ribbed, cast iron casing, which is bolted to a resiliently mounted sub-frame. The de Dion principle—a compromise between the live axle and a fully independent suspension—offers reduced unsprung weight, but the wheels are still interconnected and therefore react upon one another. In spite of this disadvantage, a de Dion rear axle layout is a feature of the new 4 litre Lagonda Rapide. Unfortunately, detailed information on the design of the final-drive unit was not available and little could be learnt from a visual examination.

The Salisbury Powr-Lok limited-slip differential is still the only one fitted to any among the British production cars.

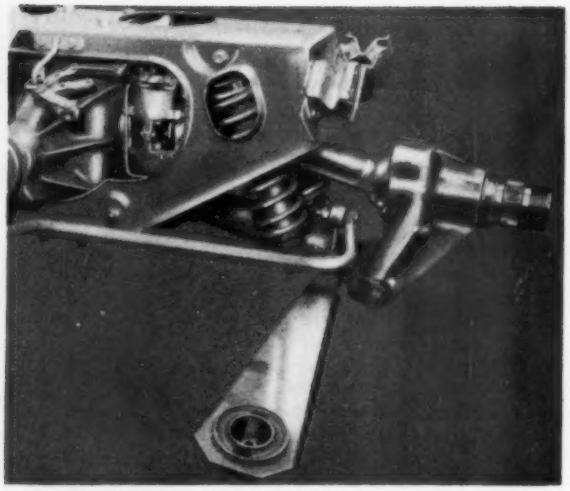




Of the two illustrations above, one shows the mounting arrangement on the Lotus Elite final drive unit, while the other is of a sectioned, angular contact, constant-velocity joint of the type used at the outboard ends of the shafts of Donald Campbell's Bluebird



Right: Half-shaft of the Lancia Flavia with Birfield constant-velocity joints at each end. That at the inner end is sectioned to show its pot type housing, which slides axially on balls to minimize friction thrust



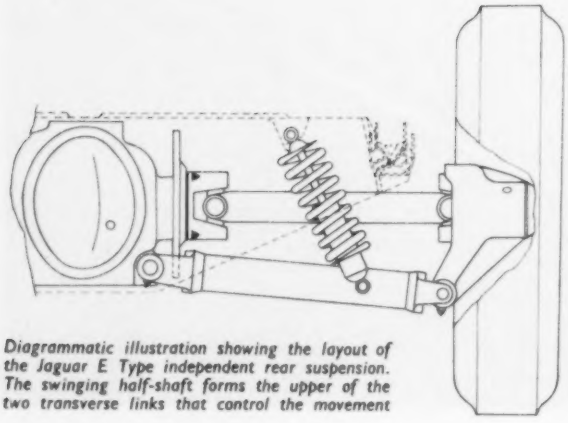
This illustration of the Jaguar E Type rear suspension shows the V-mountings at one end of the sub-frame, the anti-roll bar and, in the foreground, the Metalastik 3½ in outside diameter, slotted rubber bush, fitted at the front end of the pressed steel radius arm

Rear Suspension

Novel Form of the Hotchkiss Layout, and a New Car with Independent Rear Suspension

IN terms of numbers, the predominance of conventional suspension systems remains virtually unchanged. Most of the models exhibited this year at Earls Court again had independent front suspensions with double transverse links, and rear suspensions with rigid, live axles. There is, however, a significant addition to the slowly growing number of models with independent rear suspension; there are also other departures from commonly accepted practice, and evidence of further development of the established systems.

The most noteworthy departure from conventional rear suspension layouts, and indeed one of the most interesting springing developments in general, was the adoption of an independent system on the Jaguar E Type and Mark X cars. There are no essential differences between the original design, which was introduced with the E Type, and the version which has since appeared on the Mark X. The system comprises upper and a lower transverse arms and one trailing radius arm per wheel. Of the two transverse arms, the upper consists of a fixed-length half-shaft with a needle roller universal joint at each end, while the lower arm comprises a 2½ in outside diameter tube with forked ends. The latter pivots at one end on a downward extension of the light alloy wheel carrier and at the other on a sub-frame carrying the final-drive unit. At its inboard end, the bearings are of the needle roller type and are about 11 in apart; at the outer end, the taper roller bearings are spaced approximately 5 in apart. This lower arm serves mainly to locate the wheel transversely: longitudinal location is provided by the trailing radius arm, which is a steel pressing connecting the outer end of the tubular arm to the body structure.



Diagrammatic illustration showing the layout of the Jaguar E Type independent rear suspension. The swinging half-shaft forms the upper of the two transverse links that control the movement

At both ends of the radius arm are rubber bushes. That at the rear end is a Metalastik Ultra Duty bush, which has a spherical inner member allowing slightly greater axial movement than would a plain bush with cylindrical members. The bush at the forward end of the radius arm—that is, its body mounting—is a special, Metalastik cylindrical component, of 3½ in outside diameter and with slots in the rubber to provide greater flexibility in the fore-and-aft direction than laterally.

Each wheel suspension assembly has two coil springs, which embrace the twin Girling telescopic dampers. The use of duplicated springs leads to some economy of space, as one can be accommodated on each side of the half-shaft. The spring assemblies are mounted in rubber bushes between lugs on the transverse tubular arm and the sub-frame that carries virtually all the suspension elements. In the case of the E Type car only, the system includes an anti-roll bar, which is connected to the rear ends of the trailing arms by means of short rubber-bushed links.

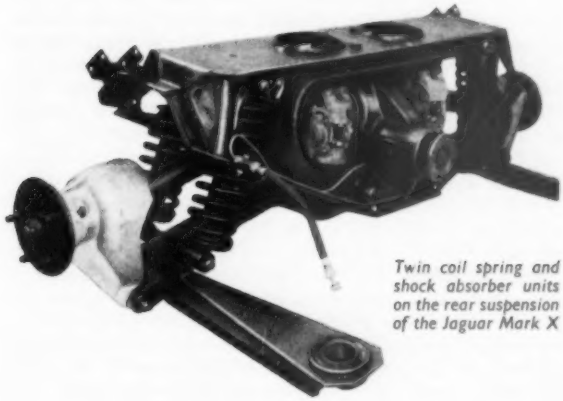
The sub-frame, or rear suspension cross member, is fabricated from steel pressings and as already indicated, carries not only the suspension elements but also the final-drive unit with the inboard-mounted disc brakes. This sub-frame is attached by means of four Metalastik V-mountings to the underside of the body structure. The rubber in these mountings is loaded in shear as well as compression, and, together with that in the mountings of the radius arms, it eliminates all metal-to-metal contact between the complete assembly and the body, thus insulating the latter from high-frequency, transmission and road vibrations. Moreover, the disposition of the two V-mountings on each side of the cross member and the longitudinal resilience of the mountings of the radius arms on the body are such that they allow the sub-frame assembly a small amount of rotational movement. Actually, the maximum movement is 5 deg under driving torque and 3 deg under braking; it corresponds roughly to the movement of a rigid live axle mounted on semi-elliptic springs, and the consequent flexibility is sufficient to absorb transmission judder. The whole sub-frame assembly can be easily detached from the body structure.

Although not strictly part of the suspension, the inboard-mounted disc brakes enhance the effectiveness of the

independent suspension system by still further reducing the unsprung weight. In fact, the unsprung weight is as much as 50 per cent less than that of the rigid axle suspension of the Jaguar Mark 2, and this obviously has a significant beneficial effect on adhesion. The behaviour of the suspension in other respects is governed by its geometry, which offers a compromise between minimum variations of camber and track. This compromise is effected by the use of parallel transverse arms of unequal length which, under static conditions, give a roll centre 5·2 in above ground, and a camber angle of ½ to 1 deg negative.

In contrast to the two Jaguar models, the new Lagonda Rapide still has a rigid rear axle. This axle is part of a de Dion suspension layout, which provides a reduction of unsprung weight approaching that obtainable with an independent system but which does not, of course, provide as great a relative degree of freedom between the wheels. The axle is located longitudinally by a pair of parallel trailing links at each side, and transversely by means of a Watt linkage. Springing is provided by transversely mounted torsion bars, fixed to the lower trailing arms, in conjunction with large, lever type dampers.

As a further contrast with the Jaguar vehicles, the closely related Aston Martin DB4 still has a rigid live axle. This, too, is located longitudinally by parallel trailing links and transversely by a Watt linkage; however, coil springs, mounted behind the axle, are employed instead of the torsion bars of the Lagonda Rapide. Twin parallel trailing links are also used to locate the rigid live axle of the Volvo P.1800, on which the resilient elements are again coil springs, mounted above the axle. In general, this type of rear suspension, with pairs of trailing arms and coil springs, represents a common first step beyond the Hotchkiss drive layout, and further examples can be found on cars such as the Buick Special and Oldsmobile F-85, which appeared at last year's London Show.



Twin coil spring and shock absorber units on the rear suspension of the Jaguar Mark X

A rigid rear axle has been adopted for the new Lancia Flavia, which has front wheel drive. The axle takes the form of a light tubular beam located on each side by a semi-elliptic spring with six leaves. An anti-roll bar is connected by short links to the axle, and the de Carbon telescopic dampers have a forward inclination, but the point of particular interest about the Flavia rear suspension is the mounting of the leading ends of the leaf springs: bolted to the end of each spring is a trunnion, with nylon bushes clamped in rubber housings.

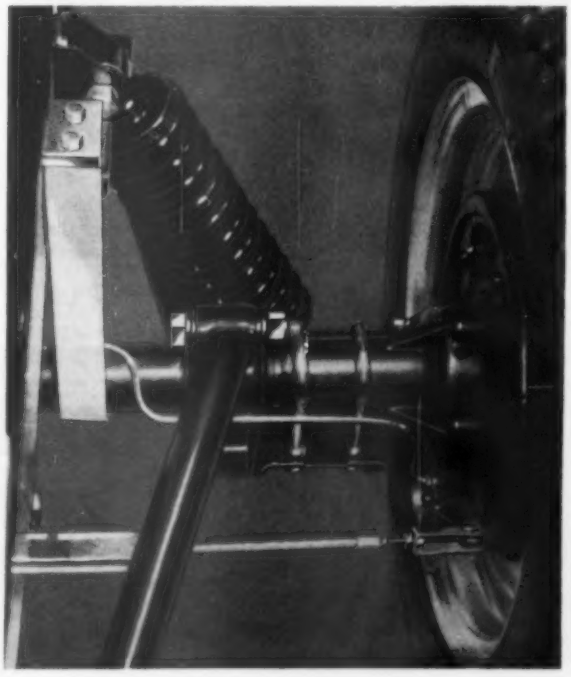
Although a rigid rear axle does not constitute such a penalty on cars with front wheel drive as on those where the rear wheels are driven, the Renault 4L, another new front driven model, has an independent rear suspension, to eliminate the reaction of one wheel on the other. As on the front driven B.M.C. ADO 15 series—that is, the Austin Seven, Morris Mini-Minor and the recently introduced Riley Elf and Wolseley Hornet variants—the suspension of this Renault is of the trailing arm type. However, in contrast to the ADO 15 cars, which have rubber springing, the Renault vehicle has transverse torsion bars.

Its trailing arms are fabricated from steel pressings, and their pivot points are some distance inboard of the ends of the torsion bars, to which they are connected by short coaxial tubes. The use of the tube connection makes it possible to install a slightly longer torsion bar than would otherwise be possible within the available chassis width; for coupling the tube and the bar, a simple hexagon is machined at the end of the torsion bar, which fits in a hexagonal hole in a sleeve forming the outboard end of the connecting tube. There is a similar hexagonal coupling at the other end of the torsion bar, which is anchored by an L-shape arm to the chassis frame. The shorter, curved part of this arm has five holes to provide alternative positions for the fixing bolt to the chassis frame; thus, the static height of the chassis can easily be altered to suit specific conditions.

Under normal conditions, the ground clearance is as much as 7·9 in, which is useful for driving on rough roads or country tracks. To help achieve this exceptional clearance, the telescopic dampers are mounted almost horizontally along the chassis rear extension members, well above the trailing arms, to which they are connected by a pressed-steel arm. A further point of interest about the rear suspension is that one torsion bar is behind the other—a practice commonly adopted in tracked armoured fighting vehicles with transversely mounted torsion bars—so the rear wheels are staggered. In consequence, the wheelbase on the right-hand side of the car is 96·2 in and on the other it is only 94·3 in.

Yet another new model with front wheel drive and

Part of the rear suspension of the Reliant Sabre: the upper arm of the splayed Watts linkage and the Girling spring and damper are shown



independent rear suspension is the Citroën Ami 6. However, although the appearance of this car differs considerably from that of the earlier Citroën 2 CV, its suspension layout is basically the same. The system was, of course, described in detail in the May 1954 issue of *Automobile Engineer*.

An unusual rear suspension arrangement has been adopted on the new Reliant Sabre. This model, like the majority of others, has rear wheel drive and a rigid live axle, but with coil springs coaxial with Girling dampers, and the axle is located by two longitudinally disposed Watt linkages: on each side there is a trailing link attached at a point below the axle and a leading link attached above the axle. These links have an outside diameter of 1¼ in and are of 10 s.w.g. steel. Kinematically, the soundness of such a linkage with a rigid axle is open to question because, whenever one side of the axle rises in relation to the other, there is a tendency for the linkage to twist the axle casing, and this effect can only be obviated by giving considerable resilience to the rubber bushes on which the links are carried. In addition, any tilting of the axle will tend to draw the two linkages together, as viewed in plan, and this movement must again be accommodated by lateral distortion of the rubber bushes. For lateral location, the tubular links are disposed so that they splay out from their pivot points on the chassis.

Hotchkiss type rear suspension systems continue to be used because of their relative simplicity and cheapness, and are being further developed. The latest practice in respect of this system is exemplified by the new Vauxhall Victor and the two new Rootes group models, the Singer Vogue and the Hillman Super Minx, which are mechanically similar. The Super Minx has a single-rate spring 50 in long and 2 in wide, compared with the 46·95 in long and 1½ in wide spring of the earlier Minx 3C. Whereas the latter Minx had an auxiliary leaf which, when brought into operation, increased the spring rate from its initial value of 114 lb/in to 143 lb/in, the spring of the Super Minx, which has a rate of 118 lb/in, does not feature this extra leaf. Thus, instead of the six $\frac{5}{64}$ in thick leaves and the one $\frac{7}{64}$ in thick auxiliary leaf, there are now five ¼ in thick leaves, of En.45A steel. However, the Metalastik Metaxentric rubber bush, which was introduced on the Minx 3C, has been retained at the front end of the Super Minx rear spring. Girling or Woodhead-Munroe rubber-bushed telescopic dampers are employed.

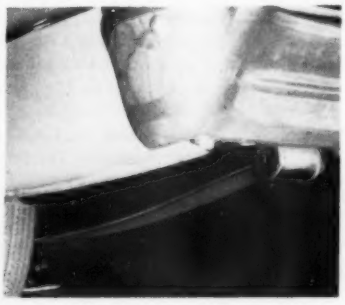
In contrast to the reduction in the number of spring leaves on the Super Minx, relative to the earlier Minx, the new Vauxhall Victor FB car has four leaves per spring, as against the three of its predecessor. These springs, also of En.45 steel, are now 48½ in long and 2 in wide, and the spring rate is 70 lb/in, whereas the previous rate was 95 lb/in. However, the higher-performance version of the new car, the VX 4/90, has stiffer springs with only three, thicker leaves, and retains the original spring rate. Two telescopic dampers are installed.

On the axle tubes are two rubber bump stops and, in addition, there is a short arm on each side, extending forward of the axle casing and carrying another rubber stop of conical form. The clearance between the arm-mounted rubber cones and the chassis is less than that between it and the axle-mounted bump stops. In consequence, at large spring deflections, as well as under severe torque reaction, the arm-mounted cones come into play first and increase the effective stiffness of the springs. Such an arrangement has already been adopted on the larger Vauxhall cars and produces a variable rate effect under extreme conditions. Another advantage is that vertical movement of the rear end of the propeller shaft is restricted, making it possible to reduce the size of the tunnel.

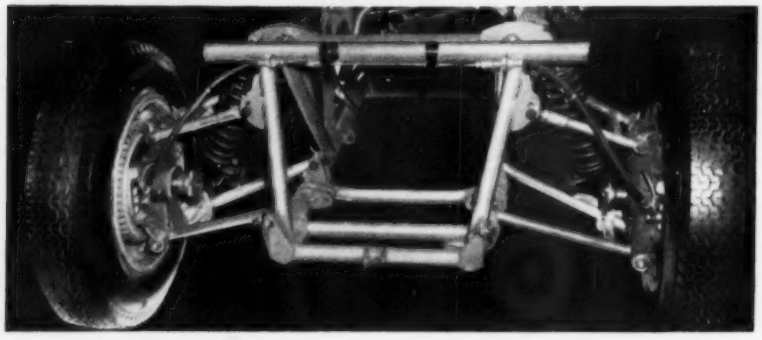
While the Hillman Super Minx and the Vauxhall Victor are examples of the latest British practice in respect of rear suspensions based on the Hotchkiss drive layout, they do not by any means represent the furthest advance in the development of this type of suspension. What is perhaps the ultimate form is to be found on the new Chevrolet Chevy II, which has a spring with a single leaf varying in thickness and width along its whole length. The thickness decreases from the middle towards the ends, but the converse occurs in the plan view, since the width is greater at the ends than at the middle.

A uniform stress distribution is claimed for this spring and, to meet the requirement for a relatively high acceptable stress level and fatigue strength, the upper surface is shot peened. This shot peening is done with the upper surface of the leaf under considerable tension, and the resultant fatigue properties are said to be up to ten times better than those acquired by the normal methods of shot peening unstressed leaves. The shot-peened single leaf spring of varying thickness and width is about 25 per cent lighter than an equivalent conventional multi-leaf assembly, and it is claimed to be ideal for Hotchkiss type rear suspensions. However, the length of the spring is considerable—60 in in the case of the Chevy II—and in some cases this may present installation difficulties. More work is thrown on the dampers, not only because of the elimination of inter-leaf friction, but also because of the greater lateral flexibility of the spring; however, the elimination of the inter-leaf friction—which can vary so much with the state of lubrication—is beneficial in terms of the ride. In view of the heavier duty, it is noteworthy that the Chevy II has only two standard obliquely mounted telescopic dampers.

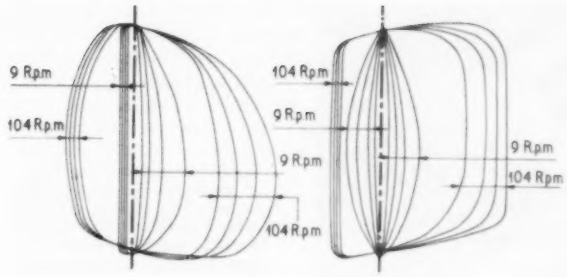
Problems sometimes created by lateral movement of the



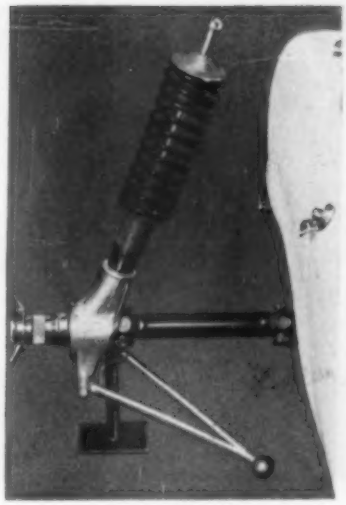
Right: Single leaf spring of the Chevy II. Its thickness and width vary from the centre to each end



Independent rear suspension of the Cooper Formula Junior car. It has twin transverse wishbone links and adjustable telescopic dampers concentric with the coil springs



Left: Typical work diagram of the Armstrong Selectaride shock absorber. The more rounded diagram is of the telescopic and the other is of the lever type unit



Simplicity is the noteworthy feature of the coil spring and telescopic strut independent rear suspension system that is employed on the Lotus Elite sports car

rear axle are highlighted by the introduction of a transversely mounted telescopic damper on the B.M.C. ADO 53 series, which includes the Austin Westminster, the Wolseley 6/110 and the Vanden Plas Princess. As before, the conventional rear suspension layout of these cars embodies two lever type dampers, which control vertical movement of the axle in the usual way. The additional telescopic damper has a negligible effect vertically, but damps lateral movement. Its function has been compared with that of a panhard rod: obviously, though, it is intended to damp out any tendency for the axle to be jerked laterally by suddenly applied side loading; on the other hand, it can also damp lateral oscillations of the axle.

The use of this device makes possible the employment of more flexible leaf springs, and therefore a softer ride can be obtained without risk of undesirable behaviour of the rear axle. The damper itself is an Armstrong GT 5 unit, in which the oil and air are separated by means of a rubber diaphragm. This separation is of course essential to prevent aeration of oil, since the damper is mounted in an almost horizontal position. Dampers of this type have been used in a similar disposition on other cars; for instance, one has been fitted as a steering damper on the export version of the Ford 105E car.

In general, almost all cars have steel springs; the notable exception is, of course, the B.M.C. ADO 15 series, which have rubber springs. There is, however, a definite trend towards an increased use of rubber, mainly in the form of improved bushes and mountings, to assist the action of the metal springs and reduce the transmission of vibrations. There are also a few examples of additional rubber units used in rear suspensions. One is the arm-mounted rubber cone on the Vauxhall cars, and another is the auxiliary spring introduced on the NSU Prinz 4. The last-mentioned car has an independent rear suspension of the swing axle type with coil springs, within which the auxiliary springs have now been mounted. Prinzair is the name given to the auxiliary spring, which consists of a cylindrical air bag with convoluted rubber walls and an internal piston-guide. It comes into operation when the coil spring has been compressed beyond a certain point and thus improves the ride when the car is heavily laden or travelling over rough surfaces.

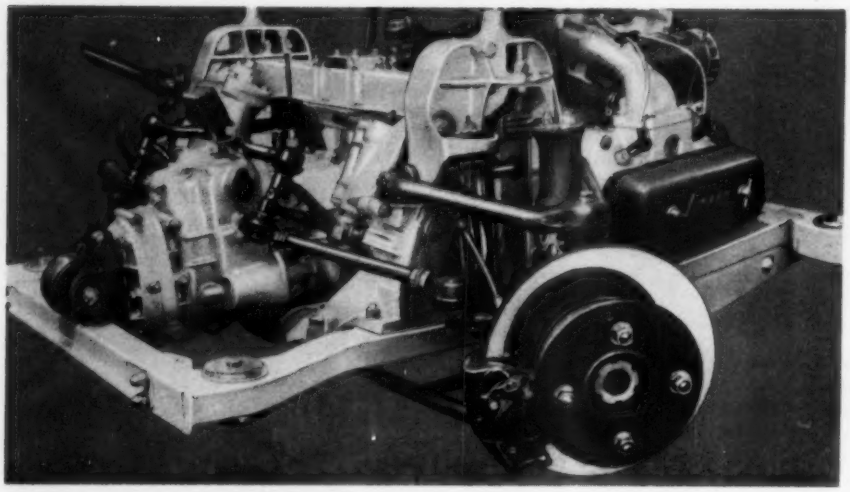
Although air springing no longer attracts the interest it did a few years ago, when it was being energetically promoted in the U.S.A, development work is continuing. Last year, the Bosch air springing system was introduced on the Borgward 2·3 litre car and this year a pneumatic layout has appeared on the Mercedes-Benz 300SE. In the meantime, production of the Borgward has ceased, but whatever augury that may represent for air springing, a similar fate is unlikely to overtake the Mercedes-Benz car.

The 300SE rear suspension is of the single-joint swing axle type, with a low pivot position and a thrust arm on each side; this design is now common to all Mercedes-Benz cars. However, the coil springs normally used with this system are replaced by air springs of the rolling diaphragm type. Similar spring units are also used at the front, in conjunction with double transverse wishbones and an anti-roll bar. Each spring unit is surmounted by an air chamber. There are two levelling valves at the front, one on each side, but only one at the rear. The rear levelling valve is operated by a linkage connected to the middle of the rear anti-roll bar, so that it responds to the vertical movement rather than roll of the body relative to the wheels.

Air for the suspension system is supplied by a belt-driven, two-cylinder compressor with a magnetic coupling to disengage the unit when the pressure in the system has reached 120 lb/in². The air is drawn through the engine induction air filter and a unit that prevents freezing of the water content. From the compressor it passes to a 7 litre reservoir and thence through a master valve to the three levelling valves. The levelling valves are made by Robert Bosch G.m.b.H. and the air springs have been developed in conjunction with Phoenix Gummiwerke AG.

An entirely different type of air spring was exhibited by Armstrong Patents Co. Ltd. It is a self-contained hydro-pneumatic damper and spring unit, which has already been described in full detail in the August 1961 issue of the *Automobile Engineer*. In essence, the Armstrong suspension unit contains a piston operated by a crank, which is connected to a road wheel of the car. The chamber in which the piston and crank operate is completely filled with oil but at each end there are nitrogen pockets, which are separated from the oil by flexible diaphragms, and which act as bump and rebound springs. Damping is provided by valves at the top of the oil-filled cylinder; a small oil pump, actuated by cams on the main spindle, provides automatic height control by slowly transferring oil from one side of the piston to the other. Unlike most other pneumatic springs, the Armstrong hydro-pneumatic units are simple to install and thus offer attractive possibilities, but they remain to be adopted and proved in service, as do other simple air springs which are being developed.

Another Armstrong exhibit, which can be applied to rear and front suspensions, was a damper with four-position remote adjustment of the valves. The control is mounted on the facia; it consists of a rotary switch, which has a click action and energizes a solenoid in the damper body. This solenoid moves a rotary valve that varies the settings of the damper valves. Both telescopic and lever type dampers are available with this adjustment, the effect of which is shown in the diagram at the head of the previous column on this page.



Suspension and steering layout of the Lancia Flavia: the large rubber bobbin connecting the end of the transverse leaf spring with the upper wishbone can be clearly seen above the wheel assembly

Front Suspension and Steering

One Recently Introduced Vehicle with Leading Arm Type Suspension and Another with a Transverse Leaf Spring; Widespread Use of Ball Joints with Impregnated Nylon Bearings, to Obviate Lubrication Points

FEWER major developments are evident in front suspension systems than in rear suspensions. The predominant layout continues to be based on twin transverse links for wheel location, used in conjunction with coil springs or, in a number of cases, torsion bars. Two of the exceptions to this, among the new cars, are the Ford Classic 315 and its Capri derivative, whose front suspensions constitute yet another example of the Macpherson system of the other British-made Ford cars. A more individual, though not entirely novel, approach to front suspension design is represented by the Reliant Sabre. In this, the front wheels are carried on leading arms, which are tubular with an outside diameter of 2 in and a thickness of 10 s.w.g. The pivot axes of the arms are inclined at 38½ deg to the longitudinal axis of the chassis, so the suspension layout is geometrically equivalent to an oblique swing axle.

By the employment of leading arms, instead of the wishbones that are sometimes used to obtain a similar effect, a more compact arrangement is obtained, but sufficiently positive location becomes more of a problem. In this instance, effective location is obtained by carrying the arms in phosphor-bronze bearings instead of rubber bushes. Coil springs coaxial with Girling telescopic dampers are fitted. They seat on the extreme forward ends of the arms.

Another unusual front suspension layout has been adopted for the Lancia Flavia. It has two unequal-length wishbones on each side, with ball joints at their outer ends, but a single transversely installed leaf spring with eleven leaves is employed; the ends of the spring are attached to the upper wishbones by relatively tall rubber bobbins. The whole of the front suspension, together with the engine and transmission unit, is carried on a large sub-frame, which is rubber-mounted at six points on the body structure so that is can be readily removed for servicing.

The front suspension of the new Chevrolet Chevy II has coil springs coaxial with telescopic dampers, but the spring assemblies are attached to the upper two wishbones. Consequently, the mounting of the springs on the chassis is high, and this helps in the distribution of the loads throughout the front end structure. The lower wishbone on each side consists of a transverse radius arm and a drag link, an increasingly popular arrangement that has, of course, been used for many years on the Morris Minor, and has already been adopted on the smaller Chrysler cars as well as the Ford Falcon. At the outer ends of the transverse links there are ball joints with sintered iron bearings. The pivot axes of the upper wishbones are inclined to the horizontal: this inclination, by producing a vertical force component opposing the dynamic load transfer, reduces front end dip during braking. It is a feature that has already been adopted on several other General Motors cars.

Basically the same type of transverse linkage is used on the Renault 4L, which has a pressed-steel upper wishbone and a lower radius arm located longitudinally by an obliquely mounted drag link. However, the springs are long, longitudinally installed torsion bars, connected at their forward ends to the lower radius arms. A short lever is fitted to the rear end torsion bar; at the outer end of the lever are several bolt holes which, together with a number of holes in the chassis anchorage, form a simple means of adjusting the torsion bar setting. The front suspension also includes an anti-roll bar and telescopic dampers, all attached to the lower radius arms, and ball joints at the outer ends of the transverse linkage.

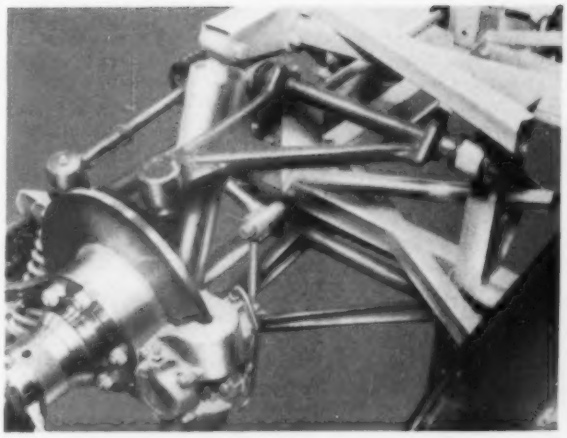
Torsion bar springing is also used on the Volkswagen 1500. In general, the front suspension of this new model resembles that of the earlier car, but differs from it in several respects. For example, the laminated square-section torsion bars have been replaced by round-section bars with splined ends. Moreover, whereas the original transverse torsion bars were connected to the upper trailing arm of the front suspension assembly on one side, and to the lower trailing arm on the

other, the torsion bars on the 1500 model are both universally jointed to the lower trailing arms and pass through the cross tube at a slight angle to one another.

The upper trailing arms are now connected by an anti-roll bar which is coaxial with their pivots. In the new model, the trailing arms are longer than before, are of H-section instead of being round, and have ball joints at their outer ends. An extension arm, on which are rubber stops, is fixed between the two trailing arms: it controls bump movement by limiting the rise of the lower arm and rebound movement by restricting the drop of the upper arm. As hitherto, the telescopic damper on each side is attached to the lower trailing arm.

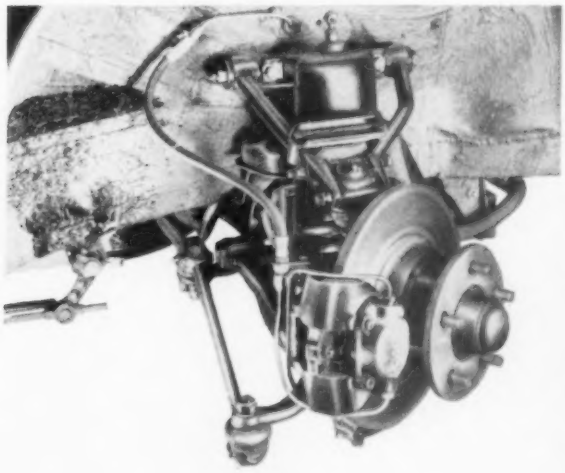
In contrast with the front suspension, incidentally, the rear suspension of the Volkswagen 1500 is virtually the same as before. The diagonal swing axle layout is retained, together with the short transverse torsion bar springs coupled to flexible trailing arms. However, the torsion bars are slightly longer than before, extending about 2 in outboard of the trailing arm pivots.

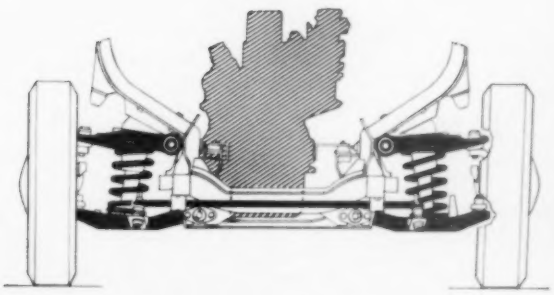
Another new model with torsion bar front springing is the Jaguar E Type. In this case the double transverse linkage consists of a neat one-piece forged upper wishbone and a longer lower wishbone made up of two links bolted together. At the outer ends there are ball joints with steel seats, and at the pivots of the wishbones rubber bushes are employed. The torsion bars are not coaxial with the wishbone pivots, but instead are splined into extensions of the front arms of the lower wishbones. This arrangement results in bending as well as torsional stresses in the spring bars, and is similar in principle to that already used on some Chevrolet trucks. Its compensating advantages are some simplification of installation, and the ability to remove the springs without disturbing the rest of the suspension. Girling telescopic dampers are attached to the lower wishbones, which are interconnected by an anti-roll bar with a short rubber-bushed link at each end.



One-piece forged upper wishbone link in the Jaguar E Type suspension

The front suspension of the Jaguar Mark X differs considerably from that of the E Type. It is still based on two pairs of transverse wishbones, and has an anti-roll bar connecting the two lower ones, but the wishbones are less elegant in shape and the torsion bars are replaced by coil springs coaxial with Girling telescopic dampers. Moreover, instead of a fabricated pressed-steel cross member, used in a number of other cars, a tubular tie bar and a forged I-section beam—reminiscent of the old-fashioned front axles—are employed to bridge the suspension units. The whole assembly is attached to the body structure by rubber





Left: Jaguar Mark X front suspension: it has a bolted two-piece upper wishbone, a three-piece track-rod, and Dunlop disc brakes are employed

Below, left: Double transverse link front suspension mounted directly on the body structure of the latest version of the Vauxhall Victor

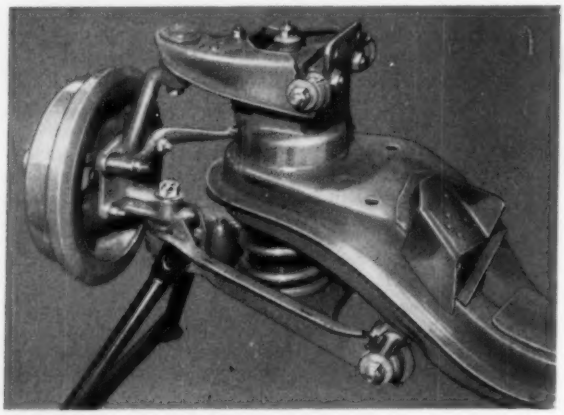
Below: The Reliant Sabre independent leading arm type front suspension

mountings, which help to attenuate road-excited vibrations. On the E Type, on the other hand, the suspension elements are mounted directly on the tubular front end of the chassis structure.

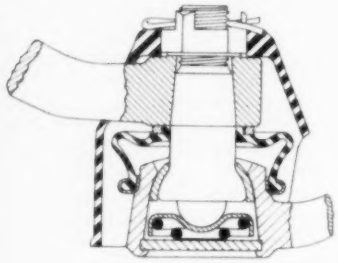
In the new Vauxhall Victor, the separate front suspension cross member of the earlier models has been dispensed with: the two front suspension assemblies are now mounted directly on the reinforced body structure. As on the previous version of the Victor, the suspension layout is of the double transverse wishbone type, and the coil springs are coaxial with the telescopic dampers; the lower wishbones are connected by an anti-roll bar. The spring rate has been reduced from 95 lb/in to 70 lb/in, and the previous screwed metal pivot bushes of the wishbones have been replaced by rubber bushes. In addition, at the outer ends of the wishbones, the combination of an upper ball joint and a lower, trunnion type joint has been replaced by two ball joints with nylon bearings; these bearings are impregnated with molybdenum disulphide and require attention at intervals of only 12,000 miles or 12 months.

Similar Thompson ball joints have been adopted on the Singer Vogue and the Hillman Super Minx. The suspension systems of these two Rootes group cars are essentially identical, and the layout is similar to that of the earlier Minx, except that the wishbones are longer. There are two pairs of wishbones, mounted on a pressed steel cross member. As on several other cars, the pivot axes of the wishbones are inclined laterally to the longitudinal axis of the chassis and are therefore sometimes described as semi-trailing, but the angle of inclination is only 18 deg. The springs have been changed and are now of 0·62 in, instead of 0·55 in, diameter En.45A steel wire; consequently, the wheel rate has gone up from 94 lb/in to 125 lb/in. As before, there are telescopic dampers mounted coaxially with the springs, but there is no anti-roll bar.

Of all the front suspension developments evident this year at Earls Court, the adoption of ball joints with impregnated nylon bearings is probably the most interesting. Last year, joints of this type were exhibited by Automotive Products Co. Ltd, but they had not at that time appeared on production vehicles. This adoption, together with that of similar ball joints in the steering linkages, and the increased use of rubber bushes, has resulted in a drastic reduction in the number of greasing points on some of the new cars. The Singer Vogue and the Hillman Super Minx, for example, have 14 fewer grease points at the front and four fewer at the

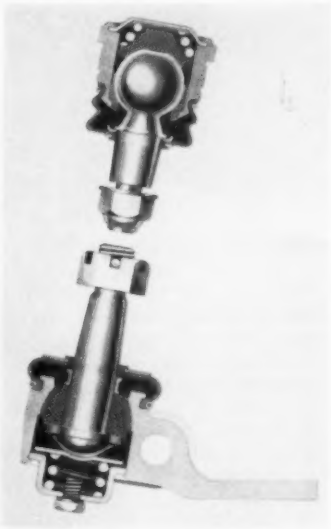


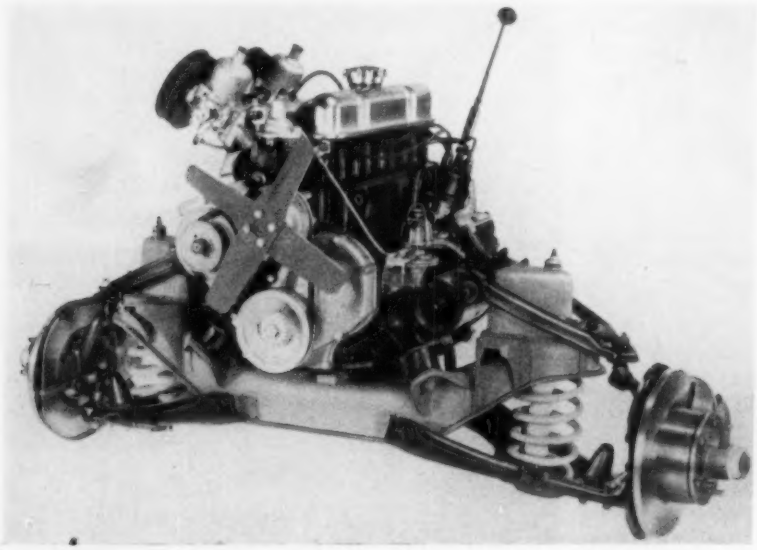
Above: Front suspension assembly of the Hillman Super Minx, with its wishbone pivot bearings and part of the cross member sectioned



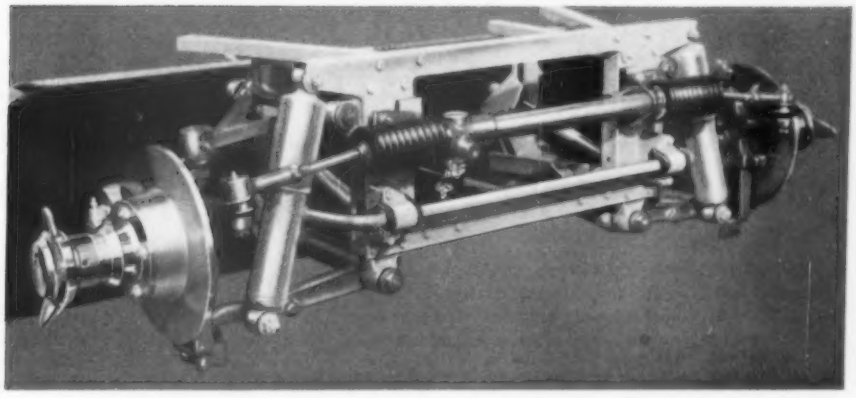
Left: Tie-rod joint for Chrysler car. It has a high quality Neoprene rubber balloon seal within a dust shield

Right: Thompson ball joints with molybdenum disulphide impregnated nylon bearings and improved rubber seals to keep them clean





The Volvo car has conventional independent front suspension, with double-transverse wishbone links, on a pressed cross member



Rack-and-pinion type steering is used on the E Type Jaguar car

rear than had the earlier Rootes group cars, and the Vauxhall Victor now has only four instead of 19.

Some of the remaining greasing points should also disappear as more experience is gained with the new components, and as some of the uncertainty about their life is dispelled. The upper ball joint, with its grease packing and molybdenum disulphide impregnated nylon bearing, should require no attention, while the more heavily loaded lower joint should require attention only occasionally, if at all. As yet, however, there is no sign of the use of such joints in the larger cars: if ball joints are used in the latter applications, the bearings are metallic, and sintered iron bushes appear to represent the next stage of development.

Steering

There is less hesitation regarding the life of sealed ball joints in steering applications than in front suspensions. Thompson joints of this type, with impregnated nylon bearings, have been adopted on the ADO 15, ADO 38 and ADO 50 series of cars manufactured by the British Motor Corporation, as well as on the Singer Vogue and the Hillman Super Minx. The secret of success of all sealed bearings lies in the effectiveness of their sealing and the care taken to prevent the entry of dirt: a good example of current practice is the tie rod end joint adopted for the 1962 Chrysler car. This has a balloon seal of moulded Neoprene rubber, with steel band reinforcement, and an exterior, boot type protector.

A novel form of permanently lubricated steering ball joint, called the Slipping Bush, was exhibited by Silentbloc Ltd. In this, the ball-pin is surrounded by a rubber element bonded to the outer cup but not to the ball. The surface of the rubber in contact with the ball is ribbed, and the spaces between the ribs form reservoirs for the lubricant. Cylindrical bushes have been made on this principle; in this case, the rubber is bonded to the inner metal tube and ribbed on the outside, where it is free to rotate within an outer metal tube. The advantage of this design of bush is that, in addition to providing the resilience of a rubber bush, it is free from the torsional wind-up of a conventional rubber type.

Another interesting item produced by Silentbloc Ltd. is the Flexsil steering column coupling, which has been adopted for the Reliant Sabre. In appearance this is a simple, natural rubber disc with four holes, but the holes are reinforced with metal inserts, which form three-piece bobbins; additional reinforcement is provided by nylon thread, wrapped round alternate pairs of bobbins on each side to a width of about $\frac{1}{4}$ in.

In other respects, there has been little further development in steering systems. Simple rack and pinion steering gears continue to be used in both high-performance cars and inexpensive light ones, while recirculating-ball type gears retain their popularity among the designers of medium-size vehicles. For example, the Jaguar E Type, Lagonda Rapide, Reliant Sabre and the Renault 4L, among several others in their respective classes, are fitted with rack and pinion steering. On the other hand, the Singer Vogue, Hillman Super Minx and the Vauxhall Victor retain Burman recirculating-ball type steering gears.

A Burman recirculating-ball unit is also employed on the Jaguar Mark X, but in this case it is used in conjunction with power assistance. The hydraulic pressure is generated by a Hobourn-Eaton roller type pump driven directly from the rear end of the dynamo. Another power-assisted, recirculating-ball steering gear is that used on the Mercedes-Benz 300SE. In this case, an American Vickers vane type hydraulic pump is used, and its pressure acts on a piston in the steering gear housing. The degree of power assistance varies, from a maximum under parking conditions down to about 70 per cent when cornering at speed.

A final detail worth mentioning is the provision of a special stop to limit the movement of the steering linkage on the Lancia Flavia. The steering system incorporates the usual three-piece track rod, and the forked drop arm of the steering box is matched on the other side by an idler lever. Mounted in the same housing as the idler lever spindle is a plunger which, when lowered, prevents the idler from turning beyond certain limits, the amount of rotation being governed by a projection on the idler lever. In this way, the movement of the steering linkage can be restricted, and consequently the wheel lock reduced to allow for the fitting of chains.

The steering linkage and front suspension assembly of the MG Midget

BRAKES

Further Progress with Disc Brakes, New Designs of Power-Assistance Equipment, and Safety Features More Widely Adopted by the Vehicle Manufacturers

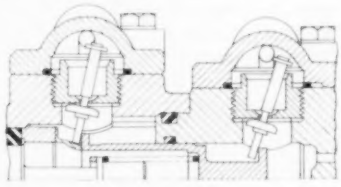
SINCE last year's Exhibition, developments in braking have been of the three kinds indicated above. There has been an important increase in the adoption of disc brakes in both standard and optional specifications. The disc brake field has been widened by the inclusion of this type on smaller British cars and a number of vehicles from German, Italian and Swedish factories. These brakes are employed on all four wheels of some of the larger touring cars, as well as on racing and sports models, but their use is usually confined to the front wheels of the smaller types. Changes in drum brake designs are comparatively few and unimportant, and consist mainly of enlargement of the drum diameter and lining area where practicable.

To provide greater stopping power with less physical effort, manufacturers have introduced a number of new designs of vacuum type power-assistance units that are applied directly to the brake pedal, thus simplifying installation and maintenance. To meet the increasing demand for a higher level of safety and reliability, divided-line braking systems are becoming more widely used; these systems have tandem master cylinders and, in some cases, transparent fluid reservoirs. Another refinement is a warning light to show when the fluid level is becoming dangerously low. Greater use is also being made of a regulating valve to limit the hydraulic pressure operating the rear brakes, the aim being at preventing wheel locking due to the weight transference to the front wheels during braking.

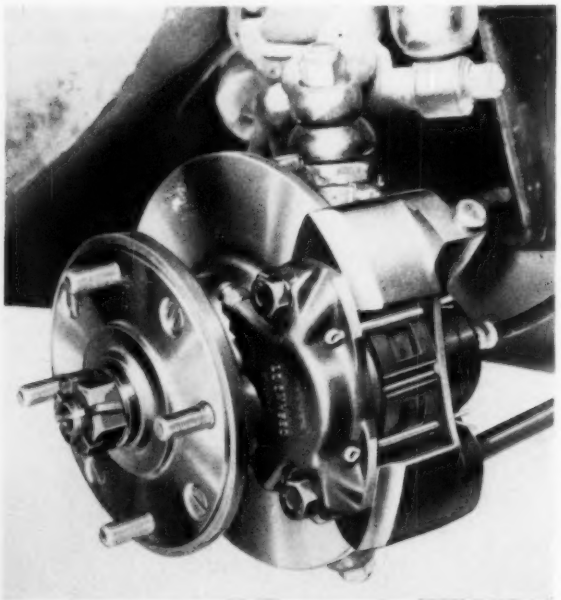
The argument against the adoption of disc brakes has hitherto been high cost: however, this is now challenged by the introduction of two new Dunlop disc assemblies specially designed for cheaper production. These are the hydraulically operated Mark III unit for front wheel applications, and the combined hydraulic and mechanical Mark IV rear wheel unit. Though basically similar to previous Dunlop designs, the Mark III brake has a cast iron caliper, instead of a malleable iron one, and only the inboard cylinder is detachable: the outboard cylinder is machined in the main casting. An external pressure-equalizing pipe connects the cylinders. The friction pads have automatic adjustment, and are held in position by steel retaining plates secured by single studs.

On the Mark IV brake, as can be seen from the accompanying illustration, the rectangular friction pads are applied to both sides of the disc by carrier plates pivoted at their lower ends to the caliper body. A slave cylinder on the inboard side, with a pipe connection to the master cylinder, actuates a pushrod attached directly to the lower end of a twin-plate operating lever, between the plates of which the upper end of the inboard pad carrier is pivoted. At the top of the operating lever is mounted a ratchet and pawl type automatic adjuster, connected by a rod to the upper end of the outboard pad carrier.

The handbrake linkage is applied also to the lower end of the operating lever, through a simple pivoted lever assembly carried on the caliper body. Running clearance for the pads, when the brake is released, is obtained by two thin brass retractor fingers mounted on the caliper body, one on each side of the disc. Since the upper ends of the fingers are attached to the pad carriers, they bend slightly when the brake is applied and straighten when braking pressure is relieved, thus moving the pads out of contact with the disc. A similar handbrake assembly, but without the retractor fingers is also available for mounting on the caliper of the standard Dunlop Mark II hydraulic disc brake unit.



Section of part of the Girling tandem master cylinder, showing the two tipping valves operating simultaneously

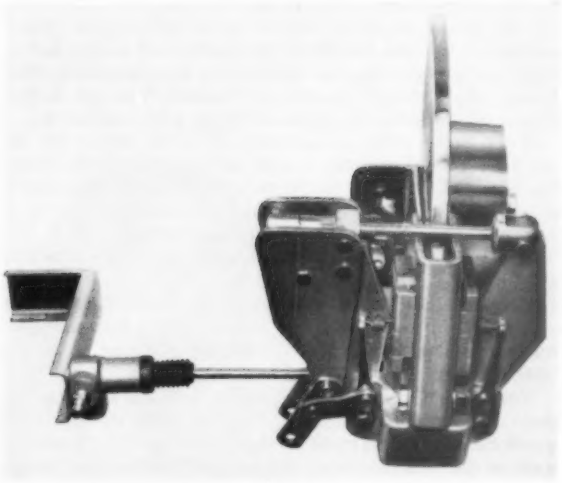


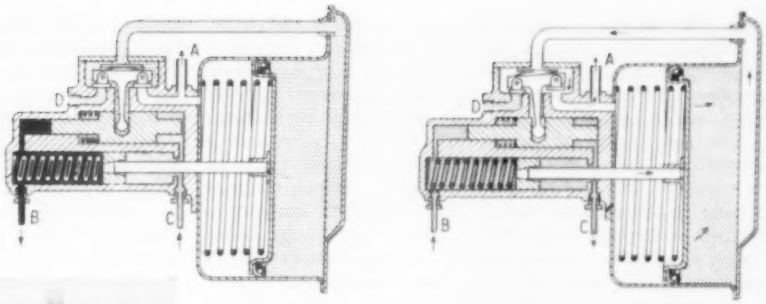
Dunlop disc brakes, with vacuum servo assistance, are fitted to the new Mercedes-Benz 300SE model. A feature of the rear brake installation is that short arms connect the calipers to the body structure. These arms transmit the brake torque reaction to the body and, since they are of the trailing type, the effect of braking is to apply a downward force to the rear of the car, thus countering the dipping of the nose, due to weight transference.

The smallest disc brake yet introduced for a production car is the Lockheed Series P unit fitted to the B.M.C. ADO 50 cars—the Austin Seven Cooper and Morris Mini-Cooper. The discs are 7 in diameter, and an area of 212 in^2 is swept by the friction pads. These pads are bonded to the pressure plates, which are held in position by a

The 7 in diameter disc brakes fitted to the Austin Seven Cooper and Morris Mini-Cooper vehicles are used with a hydraulic intensifier

Below: Dunlop combined hydraulically and mechanically operated rear wheel disc brake. On the left is the hydraulic slave cylinder, with the push-rod connecting it to the twin-plate operating lever. The two retraction fingers, at the front, control the pad clearance when the brakes are in the off position





A *to inlet manifold;* **B** *to wheel cylinders;* **C** *from master cylinder*

Diagrams of the Girling Powerstop vacuum servo unit: left, with the brakes held on, and right, with the brakes in the released position

retaining clip and split pins. The caliper, the halves of which are bolted together, is mounted ahead of the stub axle. Pad clearance is obtained by the use of rubber seals in grooves in the cylinder bores; these seals have a retracting effect on the pistons after each brake application. The new QM disc brake, which is intended for larger cars, is of similar design, with various disc diameters of 9 to 11 in.

An interesting feature of the ADO 50 cars is the new Lockheed hydraulic intensifier, fitted in the front brake circuit to compensate for the low shoe factor of the disc brakes. The intensifier has a two-diameter body, in which is a piston held in the brakes-off position by two coil springs. In the piston is an axial passage containing a valve, which is held open by its stem abutting on the end of the body. When the brake is applied, fluid passes through the valve to the brake cylinder, moving the friction pads into contact with the discs. The pressure acting on the larger face of the intensifier piston overcomes the combined effect of that on the smaller face and the two coil springs, thus moving the piston along its bore. A spring then closes the valve, so the fluid in one half of the intensifier cylinder is positively separated from that in the other half.

With further pedal depression, the hydraulic pressure on the larger face of the piston rises, forcing the piston further along the bore. This applied force increases the fluid pressure on the other side of the piston and, since the area concerned is smaller than the other, the pressure rise is greater. Therefore the brakes are applied with greater force than would otherwise be available. With release of the pedal, a spring returns the intensifier piston to the off position and unseats the valve ready for the cycle of operations to be repeated when the brakes are again applied by the driver.

Although no official data were available as to the retarding effect of the air-brake fitted to the experimental Chrysler turbine-powered Turboflite, it has been suggested that the area is insufficient to provide a deceleration of even 0·1g at 100 m.p.h. Consequently, it is questionable whether the design can justify its additional initial and maintenance costs. The flap is installed with its pivot axis transversely positioned relative to the car, and normally it is in the horizontal position, between the fins at the rear. When the brake pedal is depressed, it operates an electric switch, and the flap is rotated by motors to the vertical position. An over-riding switch on the instrument panel renders the air brake inoperative when its automatic use is not required.

The Girling disc brakes fitted to the front wheels of the new Volvo 122S/B18 car have been designed for installations where the radial space on the outboard side of the disc is insufficient to accommodate a single brake cylinder of the required diameter. Two outboard cylinders are therefore a feature of the assembly. These are of smaller diameter than is the single cylinder on the inboard side, but together they exert an equal application pressure.

Three new Girling products provide a choice of methods of obtaining power assistance for applying hydraulic brakes. One is a simple servo unit, consisting of a suspended-vacuum cylinder with a piston containing a metering valve. It is rigidly mounted for connection by a pull rod to a lever pivoted on a pendant type brake pedal. The upper end of the pedal is turned over to support both ends of a cross-pin, on to which hooks the upper end of the lever. There is therefore a rigid connection between the pull rod and the pedal. If the servo is inoperative, however, depression of the pedal can operate the single or tandem master cylinder—by means of a push rod—without moving the pull rod and servo piston. In normal operation, the balance of vacuum on

Chrysler gas turbine powered car with the air brake at the rear in the on position

both sides of the piston is destroyed by the initial pedal movement, which triggers the servo air valve. This valve admits air at atmospheric pressure to one side of the piston, causing the servo to follow up the pedal movement without delay and to provide progressive, power-assisted braking.

The new Girling Mastervac servo unit, which operates a directly attached single or tandem master cylinder, is normally mounted on the engine side of the dash, with a pushrod linkage to the pendant brake pedal. Its power chamber is connected through a non-return valve to the engine intake manifold. Prior to brake application, the vacuum port is open and the air port closed, the piston being held in its off position by a return spring. As the pedal is depressed, a valve in the piston closes the vacuum port and opens the air port, admitting air to one side of the piston, which then moves, operating the master cylinder through the medium of an internal pushrod. The resultant pressure in the master cylinder reacts through this pushrod, the valve and the external pushrod to the pedal, thus providing the driver with a degree of feel that is proportional to the applied effort. This reaction also moves the valve to a position in which both the vacuum and air valves are closed.

Further depression of the pedal reopens the air valve; more air is thus admitted and greater effort applied to the master cylinder. When the pedal is released, the vacuum port is reopened and the piston is returned by its spring, so relieving all pressure in the master cylinder and brakes. If the engine fails and the available reserve of vacuum is used up, the pedal effort is transmitted through the pushrod and piston to the master cylinder, so normal unassisted braking is provided.

Another recent Girling device is the Powerstop suspended-vacuum servo, which can be installed in any convenient position in a hydraulic brake system, with pipe connections to the master cylinder, wheel cylinders and engine inlet manifold. It operates at very light pedal pressure and functions equally efficiently in hydraulic systems of the trapped line-pressure type. From the sectional illustration, which shows the unit in the brakes-on situation, it can be seen that the piston of the power chamber acts on that of the output cylinder, to supplement the normal pressure from the master cylinder; this pressure also operates a control piston that actuates a T-shape lever controlling two valves.

When the unit is inoperative, with no pressure in the hydraulic system, one of the valves is open to the inlet manifold, and so air is exhausted from both sides of the servo piston. On depression of the brake pedal, the hydraulic pressure exerted by the master cylinder is applied equally on both ends of the piston controlling the valves. As the right-hand end of the piston is larger than the other, a greater thrust is exerted on it; the piston therefore moves to the left, causing the T-shape lever to open the valve to the atmosphere. Air is then admitted to the right-hand end of the vacuum cylinder and moves the power piston to the left. Its initial movement causes the pushrod to seal the central hole in the output piston. Further movement applies pressure on the fluid that operates the wheel cylinders and acts on the small end of the control piston.

When the thrust on that end overcomes the thrust on the large end, the control piston is moved back, closing the air valve. Both valves are then closed and the brakes are held on. Release of the pedal reduces the fluid pressure at the large end of the control piston, which consequently moves to the right. This movement causes the T-shape lever to open the vacuum valve, so air is drawn out of the servo cylinder, and the power piston is moved to the right by its return spring. In moving, the power piston takes the output piston with it, thus relieving the pressure to the wheel cylinders. Finally, the servo piston rod is withdrawn from the output piston, allowing fluid to return from the wheel cylinders.

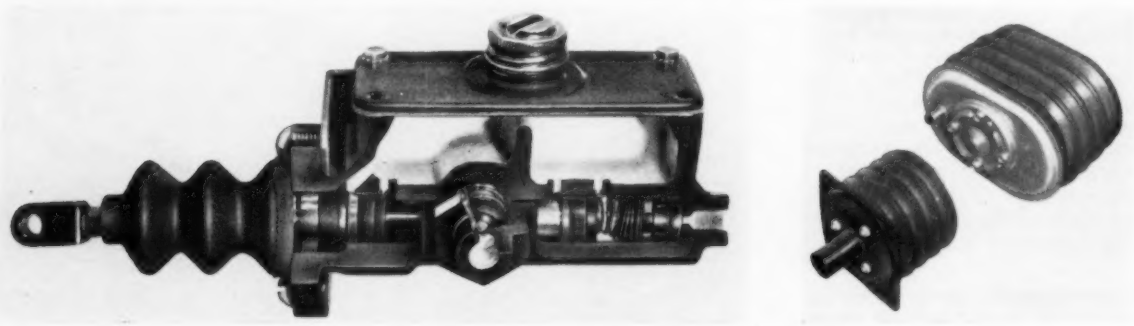
If the pedal effort is increased when the brakes are on the valve system operates to give additional assistance from the power piston, until the thrust on each end of the control piston is balanced, or until the limit of available vacuum is reached. Conversely, with a reduction of pedal effort, the valves operate to reduce the pressure at the brake cylinders until the control piston is again in a state of equilibrium. In this way, the pressure in the wheel cylinders varies in proportion to the pedal effort. It is stated that the only maintenance required is the occasional changing of the air filter element.

The latest Girling tandem master cylinder operates the front and rear brakes independently, either circuit being unaffected by damage to the other. Since there are no moving seals in the cylinder bore, scoring is eliminated and maintenance greatly reduced. The small hydraulic pressure differential between the two chambers of the cylinder ensures long life for the dividing seal. A special feature is the adoption of two tipping valves which, as shown in the appropriate illustration, have extended stems and are operated by flanges on the piston. Because the valves are opened and closed simultaneously, instead of in sequence, the ineffective pedal travel is reduced.

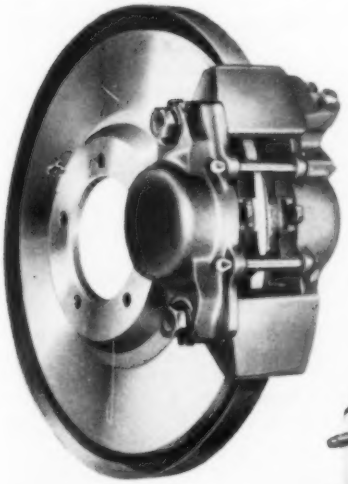
A new Lockheed design is a direct-acting, suspended-vacuum servo, which is combined with either a tandem or single master cylinder. The unit comprises a pressed steel cylindrical working chamber, to which is bolted the master cylinder; a pushrod directly connects the master cylinder piston to the servo piston, which is sealed by a rubber rolling diaphragm and is returned towards the end of the servo chamber by a coil spring. In the connection to the engine inlet manifold is a non-return valve. A vacuum passage, which can be closed off, as necessary, connects the front and rear sections of the chamber.

The control valve assembly, which is linked by means of a pushrod to the brake pedal, admits air to give the power

Illustrated on the left is the Lockheed redesigned ¾ in tandem master cylinder, and on the right are the Dunlop bellows type mechanical boosters

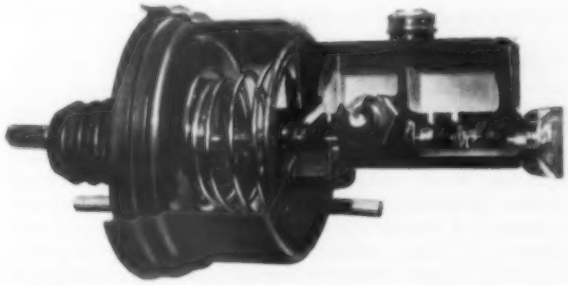


assistance. In the brakes-off position there is a pre-set clearance between the master cylinder pushrod and a rubber buffer interposed between it and the control valve. When the brake pedal is first applied, this clearance is taken up and the vacuum passage to the rear chamber of the servo sealed off. Slight further movement admits air, through a filter at the rear of the servo, to the rear chamber, and this causes the servo piston to move and boost the pressure in the master cylinder. The pressure in this cylinder creates a reaction force through the pushrod to the buffer, which acts like a fluid, applying pressure to the servo piston and extruding at its centre into the space between it and the control valve. This force, acting on the control valve, causes the air supply to the servo rear chamber to be cut off. The servo piston is then in a state of balance, the reaction force against the control valve being balanced by the load on the pedal. Since the reaction force against the buffer is proportional to the pressure in the master cylinder, the braking effort is always felt by the driver. Additional movement applied to the brake pushrod increases the pressure on the buffer, so causing more air to be admitted augmenting the force on the servo piston and hence giving an increase in the braking effort.

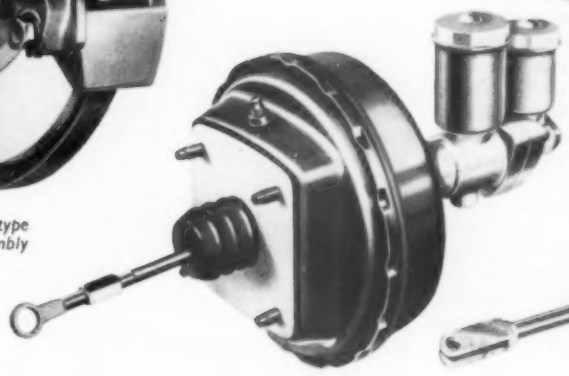


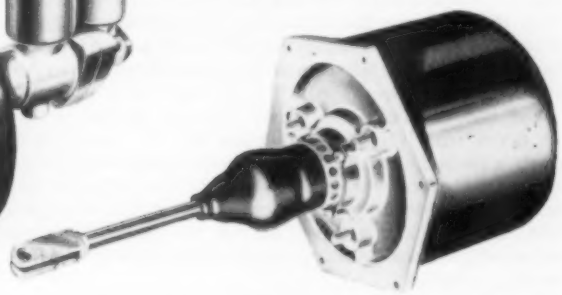
Above: Lockheed Q type disc brake assembly

Right: Lockheed direct-acting suspended vacuum servo and tandem master cylinder unit



Below, left: Girling Mastervac servo unit and tandem master cylinder. Below: Girling suspended vacuum type mechanical servo unit





For divided-line braking systems, the redesigned Lockheed tandem master cylinder embodies a reservoir divided into two chambers. For the provision of make-up fluid for the return stroke when the brakes are released, there are connecting passages between these chambers and the two pumping chambers and spaces behind the main cups, of the pistons. From the front pumping chamber, fluid flows to the brake line past a check valve at the end of the cylinder, and from the rear chamber through a radially drilled passage and a check valve at the side.

The primary piston is in the form of a sleeve, which surrounds the brake pushrod and has a return spring. Instead of being in the pumping chamber itself, the sleeve is enclosed within the protective rubber boot at the end of the cylinder. It carries the usual type of master cylinder cup, and a peg extension to which is riveted a washer, which serves as a stop for the hollow secondary piston. A spring separates the pistons to the maximum distance permitted by the stops. The secondary piston has a main cup at one end and an auxiliary cup at the other; between the two it is of reduced diameter, to form the reservoir for the make-up fluid. Beyond the secondary piston is a return spring, which is strong enough to return the complete piston assembly when the brake pedal is released, but weaker than the spring that separates the individual pistons.

When the brake pedal is depressed, the primary piston builds up pressure in the rear pumping chamber, and thus forces fluid through the check valve, to the primary brake line; simultaneously, pressure in the rear chamber forces the secondary piston along the cylinder, building up pressure in the front pumping chamber and forcing fluid through the check valve at the front end, to the other brake line. When the pressure is the same in both chambers and is equal to the thrust exerted by the pushrod, the pistons come to rest and the system is in hydraulic balance. In the event of serious leakage in the secondary brake line, pressure is still maintained in the rear pumping chamber, though brake travel will slightly increase. If the leakage is in the primary line, the secondary piston is forced along the cylinder mechanically, building up pressure in the front chamber.

Power assistance is applied directly to the brake pedal arm by the new Dunlop bellows type mechanical booster; this is similar to the model introduced last year, but is larger and more powerful. Also of bellows type is the new Dunlop coaxial suspended-vacuum servo, which is combined with a master cylinder and fluid reservoir, and is designed for mounting on the dash, with direct, pushrod connection to the pedal. The cylindrical servo chamber is divided by a metal diaphragm, which is secured to the inner surface of the chamber by a flexible rubber edging, to permit the boosting and return movements of the diaphragm. The vacuum chamber on the front side contains a coaxial bellows unit, of smaller diameter, secured to the front wall and the diaphragm; a passage of the bellows is always open to atmosphere. Carried by the diaphragm behind the bellows is a control valve assembly operated by the pushrod connection to the pedal. The braking is proportional to the effort.

Lucas mixed four-headlamp system on the Lagonda Rapide, showing how well this new arrangement can be blended into the front end styling

Electrical Equipment

Improved Four-Headlamp Arrangement, and the Introduction of Electronic Ignition Systems

OF the two main trends discernible from a study of the latest electrical equipment, the first is towards facilities for better and safer driving and the second is towards a reduction in the weight and cost of accessories, without sacrifice of performance or durability. The lighting trend is illustrated by the Lucas mixed four-headlamp and the night-day flashing indicator systems, while the new AC-Delco and Lucas electric horn designs, and the latest Lucas reversing lamp, are proof that size and cost can be reduced appreciably without disadvantage. This same trend is evident in respect of batteries: good examples of the latest practice are the AEI Extra Life battery and the Exide 3EY7 model for the Bond Minicar. Incidentally, the design of the last mentioned battery embodies some of the lessons learned during the development of batteries for guided missiles and rockets.

The introduction of the Lucas electronic ignition system for racing cars is a clear indication that the technique of spark ignition is emerging from the electromagnetic to the electronic phase. However, it is unlikely that, for some time to come, this new form of ignition will be applied to engines other than the racing type. So far, the ignition requirements of production car engines are adequately met by the existing systems.

To judge by the Lucas and Smiths exhibits, there is also a rising trend towards electric fan cooling for engine radiators. This trend has, no doubt, been influenced by the higher sustained driving speeds possible on the motorways and the consequent incentive to improve fuel consumption by reducing the power consumed at high road speeds. The electric type of fan lends itself to efficient control since a thermostatic switch can readily be embodied in the system.

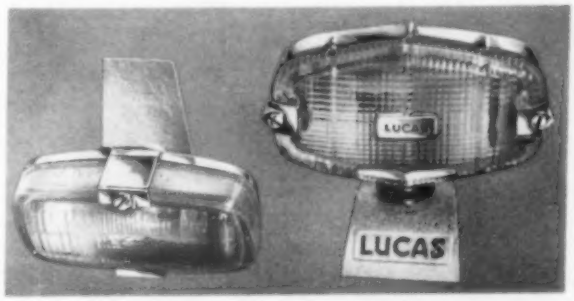
Other noteworthy developments are a submerged fuel pump to obviate vapour lock; a new range of ignition distributors to facilitate production and servicing; more powerful windscreen wipers; a stop-light switch for interior fitting; an anti-theft device; and, for car radio enthusiasts, fully transistorized receivers, one of which — a Smiths Radiomobile set—is claimed to be the first all-transistor receiver marketed in Great Britain.

Lamps, lighting and switching

It is of interest that the four-headlamp system first introduced last year on the Humber Super Snipe car has now been extended to other well-known vehicles. In introducing the mixed four-headlamp system, which comprises a 7 in and 5¾ in lamp on each side side instead of two 5¾ in lamps, Joseph Lucas Ltd. aim at providing improved illumination of the road by the meeting beam. This beam is provided by the 7 in lamp, which affords notably higher lighting efficiency and better control of beam shape than does the earlier 5¾ in unit. The 7 in lamps are provided with 60/45 W double filaments and the 5¾ in with a single 37½ W filament, giving 195 W ($2 \times 60 + 2 \times 37\frac{1}{2}$) for the main beam, and 90 W (2×45) for the meeting beam. With four 5¾ in units the main and meeting beams give 150 W and 100 W respectively; in the case of the mixed system, it is expected that in the near future, the power of the meeting beam will be raised to 100 W. The latter system is unlikely to present any increased accommodation difficulties, as is exemplified by the Jaguar Mark X and Lagonda Rapide installations.

The Lucas Lev-L Lite beam aimer components mounted on a display board

To provide service testing equipment commensurate in precision with the modern sealed-beam light units, Joseph Lucas (Sales and Service) Ltd. now offer the Lev-L Lite beam aimer apparatus, which operates on an extremely accurate split-image optical system. In essence, this equipment comprises two aimers, which are suitable for both 5¾ in and 7 in sealed-beam light units; a ready means is provided for attaching the aimers to the headlamp lenses. Headlamp alignment is effected by lining up the two aimers through viewing ports incorporated in them. Included in the equipment are transit and target components for checking



The latest design of Lucas reverse lamp is appreciably smaller than the earlier one, on the right, but its performance is not inferior

floor level, and also an error chart to demonstrate the lighting system faults to the vehicle owner. The cost of this apparatus is notably less than that of the Lucas Mark II beam setter hitherto supplied, which is still necessary for checking headlamps with separate, replaceable bulbs.

A serious problem facing the electrical manufacturers arises from the need to ensure that direction and braking signal lights are sufficiently bright to attract attention in sunshine, and yet not so brilliant as to cause annoyance to following drivers at night. However, the difficulty is confined to the rear signal lights. After extensive investigations on an international as well as a national basis, illumination intensities have been established to meet extreme day and night conditions. These figures indicate that, to cover all daylight conditions, appreciably higher intensities are necessary than those used at present, but that such intensities are not tolerable at night in the case of rear signal lights.

As a solution to this problem, the Lucas organization has introduced a night-day signalling system with an appropriate two-level light intensity. The lamps are designed to give about double the present intensities for day use; but at night, when the tail and side lamps are switched on, the intensity is reduced to about half that of the normal single-level system. Because of the difference in the viewing conditions for the front and rear lamps, the double level is applied only to the rear.

For this two-level night-day system, the lamps have had to be redesigned to provide the higher illumination intensities from bulbs of the same wattage as at present standardized. There is also a triple-pole magnetic relay, which can be conveniently mounted in the car boot. The requisite reduction in intensity at night is provided by the insertion of resistors in series with the bulb filaments. These resistors are incorporated in the relay, and are brought in when the side and tail lamps are switched on. Because the reduction in current, consequent upon the insertion of the resistors, would impair the frequency operation of the direction indicator flasher unit, another resistor is connected in parallel with the lamps, to provide an additional load and so to maintain the normal full-load operation of the flasher unit. This loading resistor is also contained within the relay unit. The modification of existing signalling systems for the two-level operation can be effected without undue difficulty; in addition to the provision of the redesigned lamps and the relay, only very minor changes are necessary to the cable harness for the rear lamps.

The new Trico-Folberth heavy-duty flasher is intended primarily for service on commercial vehicles, on which the service conditions for signalling devices are particularly exacting. In it a condenser discharge principle is employed as a means of operating an electro-mechanical relay, and the operation of the unit is unaffected by variation in signal lamp load within the rated capacity. This device is of sturdy yet lightweight construction, and is designed to operate on any load up to 6 A on either 12 V or 24 V.

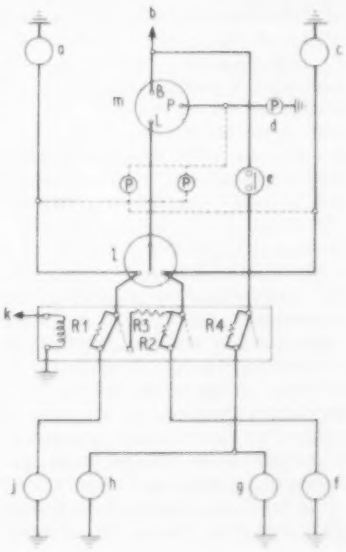
Among the Lucas auxiliary lamps is a new reversing lamp, the model L661; it is supplied complete with an illuminated switch, to conform with the legal requirement of a warning light. This lamp is of interest both for its attractive styling and for the reduction in size by comparison with the earlier model L494 lamp. Of the spot and fog lamps exhibited, the new Wipac Major 6½ in units deserve comment for their slim and elegant design.

An interesting exhibit of AC-Delco manufacture is a new mechanical type of brake light switch, specially developed for mounting on the pendant pedal. Since it is situated inside the car, instead of being exposed to the weather, it should give reliable service over long periods. The switch is biased towards the 'on' position, and rapid and clean braking of the contacts is effected after the first ¼ in of pedal depression. It is stated by the manufacturers that there is no operational lag or burning of the contacts.

As an effective solution to the car theft problem, the Lucas company has devised an anti-theft warning system in which a new master switch, designated S45, is used in conjunction with the usual switches, to give audible warning of interference. The S45 switch can be located anywhere inside or outside the car and is key operated to make the system live. By placing the master switch outside the car and using it in conjunction with door, bonnet and boot switches, warning can be given of any interference whatever, so there is a safeguard against theft both of and from a car. Alternatively, the master switch can be fitted inconspicuously inside or outside the car, and either wired in series with the ignition switch, to prevent the engine being started, or connected so that the horns sound if the ignition is switched on. The electric horn used with this anti-theft system must be suitable for prolonged operation, since the normal car horn is designed for intermittent use; replacement may therefore be necessary. Clearly, any horn relay used must also be of the continuous-duty type.

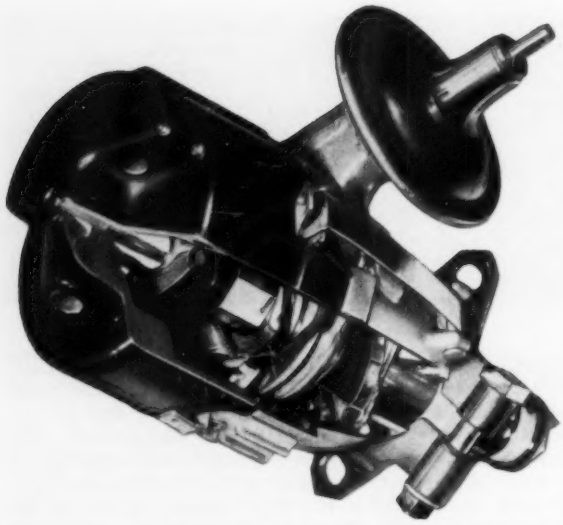
Ignition

The outstanding development in this field is, of course, electronic ignition, which has been the subject of considerable investigation in Britain and other countries for several years. The incentive behind this development has largely come from racing: for some time the racing car engine



Circuit diagram for Lucas night-day signalling system. The broken lines in the circuit show an alternative arrangement for two pilot lamps, and the broken lines between R1 and R3 and at the R2 and R4 relays show the positions for the night condition of the circuit

a and c front flasher lamps; b lead through the ignition switch to the battery switch; d pilot lamp; e brake switch; f and j rear flasher lamps; g and h stop lamps; k lead to side and tail lamp switch; l direction indicator switch



The new Lucas distributor for six-cylinder engines is similar in size to that for the four-cylinder units, and many of their components are common. The automatic timing device is of the rolling weight type, in which the hardened steel weights, under the influence of centrifugal force, roll against cams as the engine speed rises. It gives more consistent and accurate control than did the earlier mechanism

has made demands on orthodox ignition systems—in terms of spark frequencies and precision of timing—that have been increasingly difficult to meet. The advent of six-cylinder and eight-cylinder 1½ litre units, with peak speeds of 8,000 r.p.m. or more, necessitated a radical improvement.

The essence of the electronic ignition system is the relatively recently developed transistor, which can readily be employed as a solid-state switching device. Through the agency of a triggering voltage impulse, which can be induced magnetically or applied mechanically, the transistor —when normally biased to be non-conductive—is made to become highly conductive; consequently, like a closed switch or contact breaker, it permits current to flow in the circuit. The change from the non-conductive to the conductive state can occur in a matter of micro-seconds and, in any case, very much more rapidly than any mechanical device, such as a contact breaker, can operate. Moreover, the transistor does not suffer from the contact wear which, in the case of the orthodox contact breaker, is associated with rapid interruption of the current. It follows that the use of this means of controlling the primary current greatly facilitates the generation of sparks at the very high frequencies required by modern racing car engines. In fact, the spark frequencies now obtainable are well beyond those necessary for current power units. Yet another important characteristic of the electronic system is the fact that the spark can be timed with extreme precision and this accuracy maintained over very long periods of operation—a major consideration in the racing context.

The electronic ignition system developed by Joseph Lucas Ltd. has reached the stage of practical application, and has been used with success on British racing cars. It is emphasized by the manufacturers, however, that the system is still undergoing development to keep pace with the advances being made in racing engines. There is no immediate likelihood of its being applied to normal power units, since the existing arrangement adequately meets the requirements of these, from the standpoints of both performance and cost.

In the Lucas system, which was described in the April 1961 issue of *Automobile Engineer*, an electromagnetic pick-up is influenced by pole-pieces attached to the engine flywheel or, if more convenient, on a light wheel fitted to the other end of the crankshaft. The pick-up operates in conjunction with a trigger amplifier, a spark generator unit and a high-tension distributor. With crankshaft rotation, a voltage impulse is produced at the pick-up each time one of the accurately positioned pole-pieces comes within its field. This pulse is applied to the trigger amplifier, which can be regarded as a normally closed switch allowing current to flow through the primary winding of a trigger transformer. It results in this switch being opened, so stopping the current flow through the transformer.

The energy released by the consequent collapse of the primary field induces a voltage in the secondary winding of the trigger transformer, and this in turn causes a current to flow in the base circuit of the spark generator unit. An associated transistor therefore becomes conducting, and allows current to flow in the primary winding of a high-voltage transformer. A regenerative oscillation is initiated by the transistor, resulting in a very rapid increase in the primary current; this increase induces a voltage of over 20 kV in the transformer secondary winding. The high voltage is fed to a rotor arm and is distributed to the plugs in the normal way. Regeneration ceases when the transformer is saturated, and the transistor again becomes non-conducting. The complete cycle time for regeneration is less than 200 micro-seconds. With the cessation of the voltage pulse at the pick-up, conduction again begins in the trigger amplifier circuit, in readiness for the repetition of the cycle as the next pole-piece reaches the pick-up.

Latest AEI standard sealed charge battery. A heavy-duty type, which is of similar design, is also currently manufactured

An alternative electronic system is that introduced about a year ago by Performance Equipment Co. Ltd. In it a transistor is employed to assist the contact breaker of an existing coil ignition layout. In this case, the contact breaker applies the voltage impulse necessary to render the transistor conductive. The transistor then interrupts the primary current of the ignition coil. Since the contact breaker is required to handle only a very small current, contact life is greatly increased. Such a system is applicable to normal car engines but, because of the use of a contact breaker, is subject to the usual timing inaccuracies due to backlash and torsional oscillations in the drive. Moreover, the maximum operating speed is still limited by the physical characteristics of the contact breaker. For these reasons, this system could not be wholly satisfactory for racing car engines. Its present drawback, in terms of quantity production, is that transistors capable of withstanding the high reverse voltages—approaching 400 V—induced in the ignition coil primary winding are not yet commercially available. When they are, further developments are likely.

In the latest range of Lucas ignition distributors, the company's engineers have not only facilitated both production and servicing but also provided an automatic timing

mechanism of improved design. As many components as possible of the new model 25D distributor—and, in particular, the main body—are common to both the four-cylinder and six-cylinder versions; in consequence, the size and weight of the six-cylinder distributor is appreciably less than that of the earlier model. The automatic timing device incorporated in the model 25D is of the rolling weight type, in which hardened steel weights, under the influence of centrifugal force, roll against cams as the engine speed varies. This design gives more consistent and accurate control than did the mechanism previously employed. As hitherto, vacuum automatic control with micrometer adjustment is incorporated.

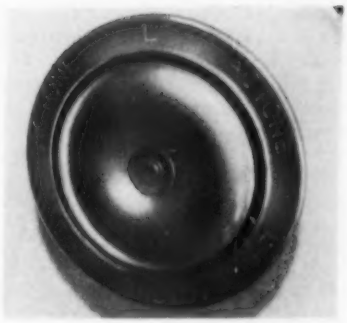
With regard to sparking plugs, it is worthy of note that Champion has developed the type UN12Y plug, as an alternative to the type N5, to obviate cold wetting when automatic chokes are used. A recent addition to the K.L.G. range is the FE75, a long-reach, integral type plug with a wide heat range; experience has shown this plug to be suitable for a large number of cars as well as motor-cycles. A version is available for marine engines also. Plugs of similar design, but which can be dismantled, can be supplied at a slight extra cost. The AC-Delco range of Hot Tip sparking plugs has been extended to cover two-stroke engines, including the outboard marine type.

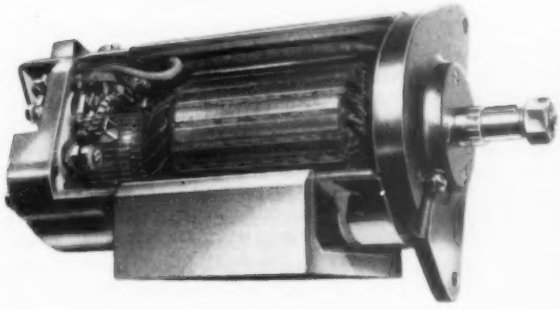
Generators and starter motors

No outstanding new features are apparent in the design of car dynamos and starter motors although Simms Motor Units Ltd. have introduced a new series of 4½ in diameter units of both kinds for commercial vehicles, including light vans. These units are of simpler design than other models in the company's range. Whereas the dynamo is, in general, of orthodox construction, the starter is of a new coaxial type, embodying a special engagement armature that moves the pinion gently into mesh with the flywheel gear. A free-wheel is also incorporated, to allow the starter to run light and so prevent overdriving when the engine fires. The pinion remains fully engaged until the starting switch is released.

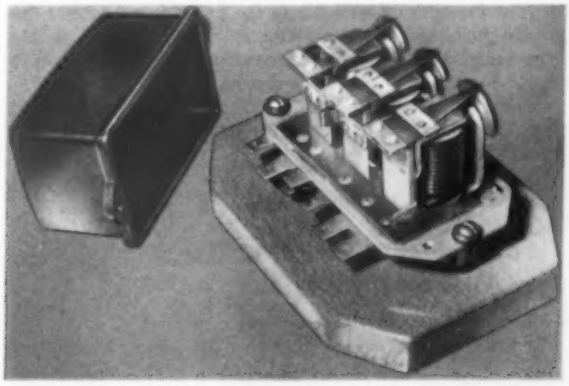
To supersede the model R310 control box, Lucas has introduced a new electromagnetically operated, three-bobbin control box. It has the designation RB340 and is intended for use with the present range of dynamos having either 4½ or 6 ohm field windings. This control box comprises two separate single-contact regulators of the vibrating-armature type. One of these regulators is responsive to current changes and the other to voltage, whereas the earlier design featured one composite relay. The third bobbin constitutes the cut-out relay. From the service engineer's viewpoint, a noteworthy feature of the new model is that toothed cams are provided on the front members of each magnet frame, and special tools are necessary to effect setting adjustment; these tools are available to garages. Variation of the settings by accident or vibration is thus precluded, and any resetting can be effected only by competent garage staff.

The AC-Delco Actone horn developed for the 1962 Vauxhall Victor, is lighter and smaller than the earlier designs and does not require a relay unit



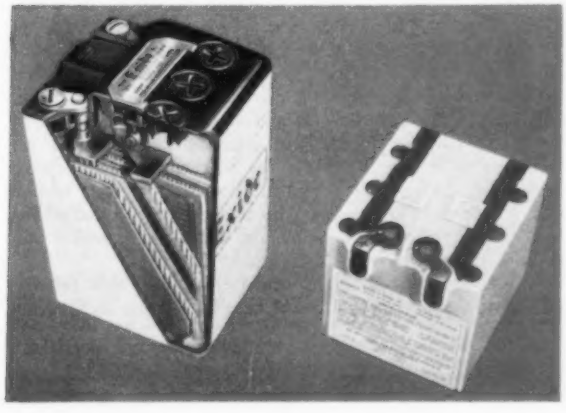


A sectioned display model of the new Simms 4½ in diameter dynamo



The Lucas control box, model RB340, is a three-bobbin assembly comprising separate current and voltage regulators and a cut-out relay

Below: Features of the Exide battery, right, developed for space missiles, have been adopted in the new 6 V, 25 amp. hr unit, which is on the left



Batteries

During recent years, a general trend in battery design has been to reduce the size and weight without impairing the performance. A good example of this trend is the new AEI Extra Life battery; since it is of the sealed charge type, it

can be stored in a dry condition almost indefinitely, if need be, and almost immediately rendered available for use at its full capacity, by the addition of electrolyte. This battery is the AEI standard unit for 6 V and 12 V systems, but the company also manufactures a heavy-duty unit of similar design, for use in any particularly arduous conditions of service.

In the Golden Crompton range of batteries, the new LCN series features a one-piece, moulded cell lid incorporating flush connection bars. This layout was adopted to improve the overall appearance, and to facilitate cleaning. As in the case of the other batteries in the Crompton range, the LCN models have a factory sealed charge. A recent addition to the Exide range is the type 3EY7 25 amp.hr battery for light cars; it is a notably compact, robust and low-weight unit. As was indicated in the opening paragraph of this section, the design of this battery derives to some extent from that of the type 6MN17, a completely unspillable model specially developed for missiles and rockets. Although this special 12 V battery is nominally rated at only a 4 amp.hr unit, it has an additional application for starting racing car engines, for which it gives several starts on one charge.

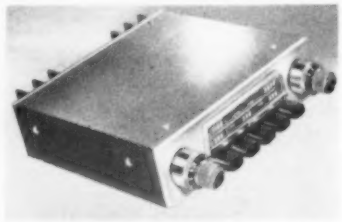
Electric instrumentation

Further development work by Smiths, in connection with the electric impulse tachometer first announced last year, has resulted in a new design of low-voltage, engine revolution indicator, which requires no direct connection to, or interference with, the ignition system. In the earlier design, the impulse was derived from a pick-up coil surrounding the high-tension feed from the ignition coil; in the new unit, however, the impulse is induced from the battery feed between the ignition switch and the primary winding of the ignition coil. In fact, this feed cable forms part of the tachometer assembly, and is looped through an iron bridge projecting from the rear of the instrument case. The loop forms the primary side of a triggering transformer, the secondary winding of which is within the instrument case and is part of a transistorized printed circuit. By means of this circuit, the moving-coil indicator is influenced according to the engine spark frequency, which is translated into engine r.p.m. on the instrument scale. As in the case of the initial design, the accuracy is not impaired by variation of either the contact breaker gap or the sparking plug voltage.

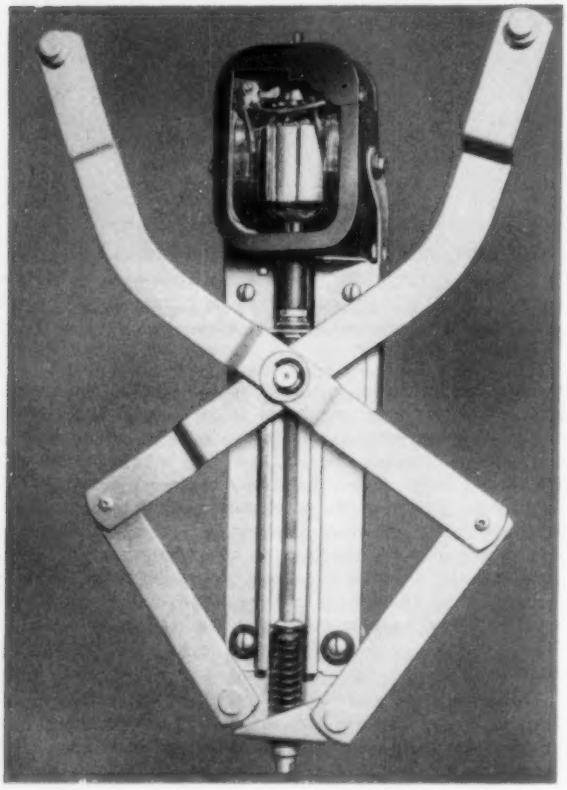
It seems likely that the use of a printed circuit in this intrument is the prelude to a wider adoption of this type of circuit for instrument panels. Among the advantages that would accrue are easier production, simpler installation, a reduction in the space required and generally cleaner appearance.

Electric cooling fans for engines

The main advantages resulting from the use of a thermostatically controlled electric fan to assist the engine radiator are more available power at high speed, with consequently improved petrol consumption; quicker engine warm-up from cold; the maintenance of an optimum engine operating temperature under all running conditions; and reduction in fan noise. Fan motors suitable for this purpose, together with thermostatic switches designed for immersion in the cooling system, are now offered by the Lucas and Smiths organizations. In both cases the coolant temperature is maintained between preset limits, the motor being automatically switched on when the coolant temperature rises above the upper limit and switched off when the temperature falls below the lower limit. The Lucas model 3GM motor, which is installed on the Jaguar Mark X car, has a current consumption, at 12 V, of between 6 and 7 A when the fan is operating. Its overall weight is 4 lb, inclusive of a two-blade fan. A refinement on the Smiths equipment, is a manual over-ride toggle switch and an indicator light, for mounting on the instrument panel in combination with a Smiths coolant temperature gauge.



Smiths Radiomobile all-transistor receiver, model 600T, the consumption of which is only 0·86 amp on a normal 12 volt supply



The Lucas model 4GM motor and the Wilmot Breeden window lift control gear installation for fitting in car doors and rear quarters

Windscreen wipers

Because of the increasing size and curvature of windscreens, and the higher driving speeds now practicable on the motorways, more powerful windscreen wipers have proved necessary. A new electric unit specially developed to meet these more arduous requirements is the Lucas model 6W wiper. The complete installation consists of the following: a two-speed motor and gearbox unit suitable for mounting on the engine side of the bulkhead; a reciprocating cable rack, comprising a central core of steel wire wound with a wire helix and passing through rigid protective tubing to a pair of wheelboxes below the windscreen; and a pair of 11 in heavy-duty arms carrying 14 in blades.

A reciprocating motion is imparted to the cable rack by means of a crankpin and connecting rod in the motor unit,

interposed between the output side of the two-stage spur gear mechanism and the end of the cable rack. The gears in the wheelboxes are the throated type, thus providing a greater area of meshing with the helix of the cable rack, and so accommodating the increased transmission load and ensuring quiet operation. Two-stage spur gearing has been adopted instead of the customary worm type, in order to improve the power transmission efficiency. Self-parking of the blades, on switching off, is another feature of this unit, and a current temperature switch is incorporated in the motor, as a means of protecting it against stalling owing to packed snow or other cause. The torque developed at the motor armature spindle is 1,500 oz-in, approximately 50 per cent greater than that which was developed by the earlier type.

Another new windscreen wiper of Lucas manufacture is the model DL3, in which a link type transmission is employed, and which operates three sets of arms and blades. It has been introduced to meet the special problem of cleaning a wide, shallow and well curved windscreen. The arms are actuated by a two-speed, self-parking electric motor, and provision is made for fine adjustment of the parking position. The current consumption, at 12 V, is 2½ to 4 A at the normal, lower wiper speed, and 2 to 3½ A at the higher speed—naturally it varies according to the windscreen condition. This wiper unit was described in the July 1961 isue of *Automobile Engineer*.

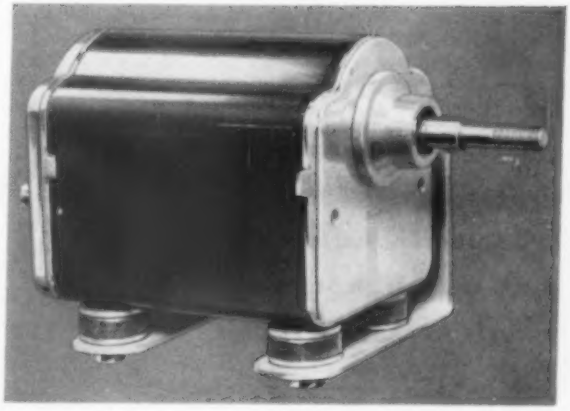
Electric horns

The main characteristic of the latest designs of electric horns recently introduced by AC-Delco and Lucas is an appreciable reduction in size and weight. The current consumption, too, has been reduced to an extent that renders a relay in the circuit unnecessary. It is understood that these improvements have been effected without any apparent loss in performance relative to that of the earlier and larger models. The new AC-Delco Actone horn was developed for the 1962 Vauxhall Victor cars and is of the type having a secondary diaphragm; no relay is required, even when a matched pair, having a high and low note, is fitted. An exceptionally penetrating and strongly directional warning note is produced, and noise inside the car is minimized.

Notably smaller than its model 618 predecessor, the new Lucas 9H wind-tone horn consumes approximately half the current and has a comparable performance. This horn is now fitted as original equipment on a number of the current cars. For compactness and light weight, the Marchal Mixo Minor TR80-2 horns are also worthy of mention: one of these weighs only 11 oz and has a consumption of 40 W. The volume of sound emitted by a pair, of high and low notes, approximate to the maximum permitted in France.

Other noteworthy accessories

Reference should also be made to two other Lucas products, the model 2FP submerged electric fuel pump and the model 4GM window lift motor. The pump was described in the July 1961 issue of *Automobile Engineer* and is mentioned again in the section of the review covering fuel systems, so no further comment is needed. Though necessarily compact, for mounting inside car doors, the window lift motor is of robust design to withstand the high shock acceleration—of the order of 70 g—to which equipment of this type may be subjected when a car door is slammed. Non-corrosive metals are used to the maximum extent, in the interest of reliability in service. The motor is controlled by a model 193SA, three-position single-pole change-over switch; in the case of a rear window duplication of the switch permits operation of the window by either the driver or the passenger. Thermostatic protection is provided for the motor and the circuit, which is under the over-riding control of the ignition. Overloading of the ignition switch contacts is obviated by the incorporation of a relay. The consumption, at 12 V, is approximately 9 and 12 A for window lowering and raising respectively.

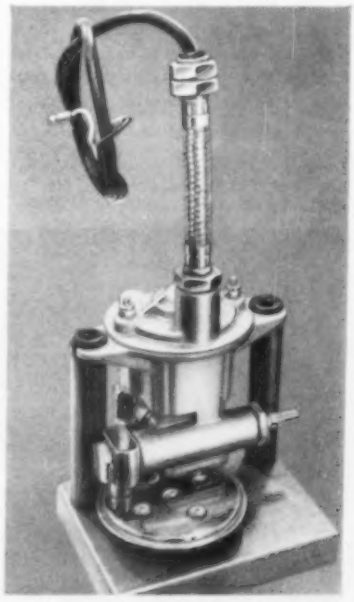


The Lucas 36M fan motor for engine cooling radiator installations

Car radio

A prospective purchaser of a car radio set, with no preconceived opinion, will not find it easy to make a selection from the wide and attractive range of sets now available from such well-known makers as Ekco, Philips, Pye, Smiths Radiomobile and World Radio. Maybe the price or a particular styling will narrow the issue, but even then the decision will probably call for careful consideration. The prices range from 18½ to about 30 gns, according to the output, quality and refinements required.

The completely transistorized receivers now available are the Smiths Radiomobile 600T range, fitted with six or nine transistors and two crystal diodes, and the World Radio Motorola sets, which have five or seven transistors and two crystal diodes. Both these ranges have push-button and manual tuning. The current consumption is very low: in the case of the Smiths Radiomobile range, it is only 0·86 A on the 12 V supply for which they are designed.



This new submerged electric fuel pump, Lucas model 2FP, is capable of delivering 20 gal/hr under conditions typical of normal vehicle installations

Many New Models; British Cars Designed for the American and European Markets; A Generally High Standard of Body Engineering Evident

Singer Vogue saloon, with its traditional upright grille styled in harmony with the modern Lucas paired headlamp arrangement

BODYWORK

THE styling of the latest British cars is aimed at acceptance overseas—especially in the U.S.A. and Europe—as well as in the home market. In general, the engineering of the bodywork exhibited at Earls Court was sound and showed further improvements as a result of lessons still being learned in the export fields. The British engineer—who is at least the equal of his foreign counterpart—now faces the challenge of designing bodies to suit the new suspension, power and transmission systems that will shortly be introduced in his cars.

Styling

Over the last twelve months, body styling in Britain has steadily advanced in line with world trends. This is exemplified by the two new versions of the B.M.C. ADO 15, the Wolseley Hornet and the Riley Elf. Their body lines reveal some Continental influence, but the frontal appearance follows tradition in that upright, dummy radiator cowls are retained.

Obviously, the Ford Motor Company's styling and design are aimed at long-term acceptance by the public. The body of the Anglia saloon has no major changes, but the Anglia Estate Car has been added to the range. Completely new, however, are the new Consul Classic 315 and Capri, which are notable for prominently pressed waistlines extending back to the outwardly peaked rear wings. American influence is shown by the manner in which the front wings and bonnet project, as cowls, over the paired headlamps.

American influence is evident in the front end styling of the Consul Classic 315, with its hooded wings, four headlamps and overhung bonnet

The Hillman Super Minx represents a further improvement in the Rootes group's basic body styling. Its sides have clean lines, and the gently curved body-side flows into an outwardly peaked rear wing. This car has a full-width grille flanked by the headlamps, above which are the combined side and indicator lamps. Although the Singer Vogue has a body shell similar to that of the Super Minx, its detail styling is different and it has paired headlamps.

There can be no doubt that the Jaguar Mark X ranks as a fine achievement. Its traditional radiator grille, which now has a slight forward rake, is smaller and neater than that of the Mark IX saloon. Twin headlamps are mounted on each side of the radiator grille in the front panelling of the wing and bonnet, which has the same rake as the grille; the resulting sporting aspect will undoubtedly appeal to American customers. Simplicity and elegance are combined in the body side lines. One pressed moulding line extends the full length of the body, dropping slightly towards the rear and blending into the surface of the panelling at the tail lamp. The crown line of the front wing sweeps upward to the waist, and then falls gently again as it flows into the crown line of the rear wing, finally curving down to the raked tail lamp unit. Although the rake of the screen and the back light is greater than hitherto, the roof panel retains the form that has been a distinctive feature of Jaguar cars for many years.

Another car that features peaked body-side lines is the new Vauxhall Victor. This car has well-balanced front and rear aspects, and in general its styling resembles that of some of the American compact cars. Few will deny that Vauxhall's latest 1½ litre car, with its trim appearance, large glass area and increased accommodation, is a marked improvement on its predecessor.

On most British cars, the external bright decoration is restrained. For bright trim, the conventional materials are stainless steel and chromium plated mild steel, brass or zinc-base alloy, but polished anodized aluminium has made small inroads into this field. Interior decoration and trim materials are considerably improved relative to those of the cars exhibited last year. A significant factor in this respect has been the introduction by I.C.I. of a new range of p.v.c. covering materials, having a damask-like sheen. Two-tone trim schemes contrast well with the monotones of last year's models. Added comfort in seating, and better carpeting and heating are also evident in the quantity produced cars.

There has been an increase in the number of models that are simply variants of one common design. As many as four variations—standard, de luxe, super and special—may be offered, differing only in paintwork colour schemes, exterior bright work, mouldings and internal trim and decoration. As for the future, it is apparent that the current trend towards American lines in styling will continue, so far as the medium and large size family-saloons are concerned, but some restrain will undoubtedly be exercised to meet the requirements of European taste.

Although it is probable that the overall height, particularly of our larger cars, will be further reduced in the future, extremes will, of course, be avoided, because of the difficulty of entering or leaving a vehicle of very low build. More attention is likely to be paid to passenger comfort, especially by the provision of seats of greater width. The current Italian influence should continue to be felt in respect of the styling of the smaller British cars.

Body engineering

There have not been any radical changes in the basic conception of the body structure, the unitary type being still by far the most common. In the smaller cars, strength and rigidity are afforded largely by the box-section side sills, and the front and rear transverse members, to which the floor pressing is welded. Generally, the front transverse member supports the front seat, while the rear one forms the heelboard of the back seat and has box extensions connected to the wheel arches, which are attached to the quarter panels, and closed by the lower panels of the rear end structure. At the front, the main floor pressing joins the dash and toe board panels, and the base structure is completed by the wheel arch side panels, which extend from the A post to a front bulkhead or cross member.

Medium-size cars of unitary construction depart little from the layout just described, but generally have an added underframe structure, in the form of longitudinal box-section members. These members are situated inboard of the side sills, giving extra support to transverse members between these sills; they extend forward of the dash structure, to the front bulkhead, and back to the rear end of the body structure, where they join the rear cross member. The same pattern is followed in the case of larger cars, although the structure is naturally of a more robust nature. In some instances, the sills are of double-box form, and there are additional box members across the dash. Inclined struts, one at each side, meet the A posts at the bottom of the windscreen pillars, and extend down the dash to the longitudinal members carrying the front suspension.

Materials

The materials used currently in car bodies are much the same as in previous years; sheet steel is, of course, generally used for the body structure and panels of the quantity-produced cars. For certain batch-produced vehicles, made in relatively large numbers, a composite construction continues to be employed, the body panels being of aluminium. Some of those made in small quantities, however, still have aluminium, steel and hardwood structures. Glass reinforced polyester resin is now well established for other batch-produced cars, and a good surface finish on this material is now usual. Bodies of composite construction are usually separate units, mounted on chassis frames of the platform, tubular or box member type.

Bright finished, anodized aluminium, of 99·7 per cent purity, is now an economic proposition and is making steady inroads, in the motor industry, for decorative purposes. In the form of rolled or extruded bars, riveted to vertical steel stiffeners, it is becoming increasingly used for external components such as radiator grilles. An alternative form for grilles is a ribbed aluminium mesh, with a finely pierced pattern. This material has a good appearance, and is suitable for screening unsightly body structure behind the grille.

Impressed aluminium is also used now for interior components such as bezels and escutcheons, examples of which can be seen on the new Vauxhall Victor and the Austin A.40 Mark II saloon. Other aluminium parts to be found are wheel disc embellishers, sill finishers and kick plates. Stainless steel is extensively used both as exterior and interior decoration, rolled sections being used extensively for applied window frames, clip-on body side mouldings, ventilating louvres, opening quarter-light frames, grille bars, pressed radiator grilles and headlamp surrounds.

Supported and unsupported p.v.c. is widely employed as the main trim covering material for cars in the lower and medium price ranges. The unsupported type is used where welded joints and impressed patterns are required. Vacuum-formed p.v.c. coverings are applied where shaped body structures are required to blend with the general interior trimming.

Vacuum-formed Royalite or p.v.c. has been used in some instances where the stylist has called for a shaped facia panel top; by backing it with moulded polyurethane foam of adequate firmness, a degree of protection can be afforded

Above: Wolseley Hornet version of the B.M.C. ADO 15, showing how the boot arrangement differs from that of the original design

Right: The two-door Ford Consul Capri features the now fashionable high peaked body sidelines and a low and slender roof

Left: The Mark II model of the Austin A.40 has a wheelbase 3½ in longer than that of the Mark I, and a wider grille is fitted

The radiator grille of the Morris Oxford traveller also has a laterally extended grille, featuring horizontal bars and carrying the two flashing indicator lamps

to the occupants in the event of a crash. Examples of this arrangement are to be seen on the Vauxhall Victor and the Hillman Super Minx. On certain models, one manufacturer is now bonding the inner panels of boot lids and doors to the outer ones. This method of construction gives an inherent rigidity and protection against rust, especially where clinched, flanged joints are used.

Among the trim materials that have recently been introduced is Hytone plastics matting backed with sponge rubber. This is a product of the Dunlop General Rubber Goods Division, of Cambridge Street, Manchester. It is claimed that the non-slip surface of Hytone is easy to clean, fade resistant, sound absorbent, and unaffected by oil and grease. The plastics and rubber layers are formed in one piece during manufacture, and there is no need for a felt underlay between this covering and the floor of the vehicle.

Individual models

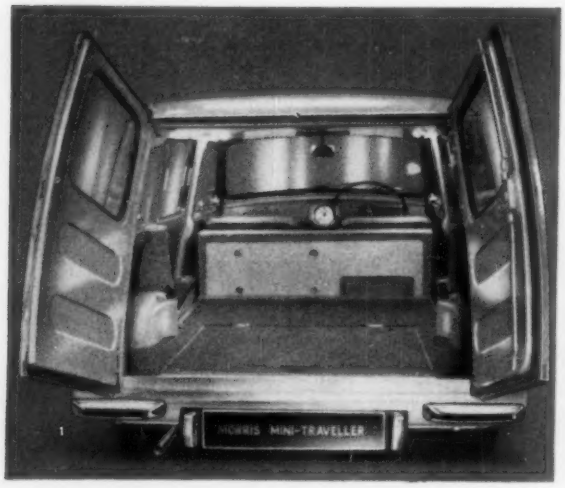
Considerable changes have been made by the Austin Motor Company Ltd. to the 1 litre, 1½ litre and 3 litre Farina styled vehicles, which now have the designations A.40 Mark II, A.60 and A.110 respectively. Structurally, these cars differ little from their predecessors, but the underframe portions of all three types have been modified to lengthen the wheelbase; in addition, both the front and rear tracks of the A.60 car are greater than those of the A.55 model.

On the A.40 Mark II, the wheelbase is longer by 3½ in, and advantage has been taken of the more rearward position of the wheel arches to widen the rear seat and to increase the leg room. As on the Mark I version, the rear squab folds forward to provide increased luggage space. A further improvement in this connection is that the seat cushion also now hinges forward, thus allowing the squab, in its folded position, to be aligned with the luggage floor behind the seat.

There is a new facia, with a black crackle paint finish; above the facia is a moulded fibre-board panel, which is padded and covered with grained, black p.v.c. material. The bezels of the switches and heater controls fitted to the facia panel are of anodized aluminium. Along the bottom edge of the facia panel and the glove box lid is fitted a shock-absorbent roll of moulded polyurethane foam with a black p.v.c. skin. A wider frontal grille has been adopted, incorporating the combined side and flasher lamps.

The A.60 features a full-width frontal grille of ribbed, anodized aluminium mesh, which is inset from its chromium plated surround; this surround embraces the side lamps,

To increase the luggage space in the Morris Mini-Traveller, the petrol tank and the spare wheel have been re-sited under the floor



On the Riley Elf, a walnut veneer facia board is employed. The instrument panel is centrally positioned, with glove-boxes on each side

which are mounted directly below the headlamps, in line with the bumper overriders. In this case, the wheelbase has been lengthened by 1 in, and the increases of track are $2\frac{1}{16}$ in at the front and $1\frac{1}{4}$ in at the rear. As a result, the rear seat passengers have a worthwhile amount of additional space.

Along the body sides are two full-length, chromium plated beadings; they are separated vertically by about 4 in and sweep gently downward from front to rear. When the body has a two-tone finish, the space between the beadings is painted in the contrasting colour. The crown of the rear wings has a falling line that reduces the height of the rear ends of the fins and blends well with the beading lines. This change has necessitated restyling of the rear lamp groups, which are aligned with the bumper overriders. The facia now has an imitation walnut finish, and a cowled and padded top with a black p.v.c. covering.

In the Austin A.110, the comfort of the rear seat passengers has been enhanced by moving the axle and wheel arches 2 in further to the rear than on its predecessor, the A.99 car. As in the case of the A.40 Mark II and the A.60, the frontal grille and the facia panel have been restyled. The grille consists of horizontal, chromium plated bars inset from the surround, which is also plated and is between the wings.

On the Austin-Healey Sprite Mark II, the headlamps are wide apart in the front wings, and the grille is of pierced and ribbed aluminium

So-called Super de luxe saloon versions have been added to the existing standard and de luxe range of Austin Seven and Mini-Minor cars. These new models are distinguishable from the others by the different frontal grilles, which have additional vertical beadings, and by the overrider bars fitted to the front and rear bumpers. The lower body-side finishers, which run the full length of the body, are stainless, chromium iron beadings, as are the window frame finishers. Two-tone colour schemes have been adopted for the interior trim, and there are vacuum-formed, black p.v.c. coverings on the lower rail of the screen and the shelf rail. Above the middle of the shelf is an oval-shape instrument panel. A refinement on these cars is a detachable luggage floor, which covers the spare wheel and the battery in the boot; the floor is of plywood and is carpeted to avoid damage to the luggage. Additional under-carpet and floor felt has been installed to improve the degree of sound deadening.

Other additions to the B.M.C. range of small cars are the Austin Seven Cooper and the Morris Mini-Cooper models, which were described in the October issue of *Automobile Engineer*. The bodywork of these vehicles is basically identical to that of the standard, de luxe and Super saloons, but the frontal grilles are different. On the Austin version, the grille comprises narrow, horizontal bars of angle section anodized aluminium; the Morris grille has broader bars of chromium plated brass. These models are further

Basically, the bodywork of the Austin Seven Cooper and Morris Mini-Cooper is identical to that of the standard saloons, but the radiator grilles are different: this is the Austin version. The Morris grille has broader bars of chromium plated brass instead of the angle-section anodized aluminium bars in the version illustrated above

distinguished by new badges on the bonnet, and name plates on the boot lid. The floor structure has small modifications to accommodate the remote-control gear lever, and the altered engine rear mountings.

Although the station wagon versions of the Austin Seven and the Morris Mini-Minor are externally unchanged, luggage space behind the folding rear seat has been increased, by resiting the petrol tank beneath the floor. The filler neck of the tank passes through a depression in the body side panel, behind the wheel arch. Under the detachable luggage floor is housed the spare wheel, the battery now being installed beneath the rear seat.

Two newcomers to the London Show were the Wolseley Hornet and the Riley Elf, both based on the B.M.C. ADO 15 saloons. They have basically the same unitary primary structure at the ADO 15 models, but at the rear end, the profiles of the boot lid and wings have been changed to increase the space available for luggage: the boot is flanked by small horizontal fins, at the rear of which are mounted the tail lamp units. This changed styling has increased the overall length by approximately $8\frac{1}{2}$ in relative to that of the original body.

On both these vehicles a small version of the maker's traditional radiator shell is incorporated at the front of the bonnet panel, which has concealed hinges at its rear edge. On each side of this shell is a decorative horizontal grille, a zinc alloy diecasting, carrying the combined side and flasher lamp. The luggage compartment has a flat, detachable floor above the spare wheel and battery. Its lid, which has concealed hinges beneath the waist rail of the rear light, is supported in the open position by a telescopic stay, and is fitted with a slam lock opened by means of a push-button.

Whereas the interior trim styles of the Hornet and the Elf differ, the seating arrangements for both models are alike. On the Wolseley, the oval-shape instrument panel and the padded screen rail and parcel shelf edge resemble those of the two Super models. The Riley Elf, on the other hand, has a full-width walnut veneered facia panel, fitted between the screen rail and the parcel shelf, with centrally mounted instruments.

The Daimler SP.250 sports car and the Majestic and Majestic Major saloons are continued without significant change, but this company's limousine is entirely new. It is intended to provide comfortable and fast long-distance travel for up to eight persons, and there is space in the boot for a large amount of luggage. The all-steel body is

mounted on a frame of conventional design, and the four wide doors have concealed hinges.

Ventilating louvres are embodied in the windows of the front doors. An inclined, fixed division, with a sliding glass panel, separates the front and rear compartments; and the two forward-pivoting occasional seats, which have hinged squabs, fold neatly into its rear face. Two interior heating systems are installed, one for each compartment; each is individually controlled from its own compartment, and the front one incorporates demisting equipment and a fresh-air intake.

On the stand of the Ford Motor Co. Ltd, the novelties were the Capri model and the Anglia Estate Car, which supersedes the 100E Escort vehicle. The Capri, a fixed-head, two-seat coupé, is a development of the Consul Classic 315, described in the June issue of *Automobile Engineer;* for the present, all production of it is reserved for export. Both the Capri and the Classic 315 two-door model have a common unitary structure up to the waistline. It is based on box section sills and two pairs of longitudinal frame members of inverted top-hat section. The front members project forward from a full-width box section cross member, under the floor, beneath the front seats. They lie inboard of the wheel arch valances, and their leading ends are welded to the front cross member.

The rear longitudinal members extend rearward from the spring brackets on the heelboard panel, and pass inboard of the wheel arches, to the rear skirt panel. At the toeboard of the front seats and the heelboard of the rear seat there are short, transverse members of inverted top-hat section that connect the longitudinal members with the body sills. To these transverse members are welded brackets that form jacking points.

An inner and an outer pressing form the bonnet, which has concealed hinges at its leading end. No stay is required to support the bonnet in its open position and, when it is closed, two spring-loaded peg type locks hold it securely to the dash. The doors are of conventional construction and have concealed hinges on their leading edges. An interesting feature is a device that spring loads the door towards the shut or open positions, once an initial resistance in the appropriate direction is overcome. It consists of a wide, curved cantilever spring with a curled end, bolted to the leading edge of the door and operating round a vertical pin on the standing pillar.

Ford Anglia estate car with rear seats folded and tail door lifted

The boot lid is constructed of two main pressings, the inner one of which is in the form of a peripheral frame and a V-shape bracing, of flanged U section. Metal-to-metal adhesive is used for bonding the flanges of the inner panel to the surface of the outer panel, the edges of which are clinched over. Slots are pierced in the bottom of the U section of the inner panel, to permit drainage during the rust-proofing and painting operations. The concealed hinges of the lid are loaded towards the open position by a powerful helical spring. To enable the best use to be made of an already large boot, the spare wheel is stowed upright behind the left-hand wheel arch. Closely spaced rectangular panels of bitumen-base material, measuring approximately 12 in × 8 in, for sound deadening, are stuck to the inner surfaces of the rear wing panels.

Structurally, the only major differences between the Capri and the Classic is in the roof unit. The relatively flat roof and reverse raked rear light of the Classic are replaced in the case of the Capri by a roof that has a gently falling, curved line from the top of the windscreen to the rear decking; this line is, of course, followed by the large rear light. Since the door lights are unframed at their rear edges, and the quarter lights wind down—on an arc—out of sight, the sides of the Capri can be completely open for driving in hot weather. Conventionally hinged quarter lights are featured on the two-door version of the Classic, whereas the four-door saloon has a winding and a fixed light on each rear door.

It will be agreed in most quarters that the Austin Healey Sprite Mark II is a great improvement over the Mark I version. The headlamps have been moved out to almost the full body width, and the body profile has been altered to give a greater impression of length and low build. A wide grille, of horizontally ribbed aluminium mesh, is recessed in a chromium plated surround of relatively broad section. The side lamps are mounted beneath the headlamps, half-way up the grille.

It will be recalled that, on the Mark I car, the complete front end hinged upward for access to the engine; on the Mark II version, however, the wings are part of the fixed structure, and the bonnet lid is hinged at its rear edge. The boot now has an external, lockable lid, whereas access was previously from behind the seats. In spite of the altered appearance, the basic underbody structure is similar to that of the Mark I version. Apart from differences in respect of the radiator grille and the interior, the new M.G. Midget is identical with the Sprite Mark II.

The new Hillman Super Minx, shown for the first time at Earls Court, is of unitary construction, with integral front and rear wing panels. Its underbody structure is of the conventional design, based on box section sills, and front and rear longitudinal members, which support the main floor pressing; the main cross members are situated beneath the front and rear seats, and between the rear wheel arches. From the dash structure, the wheel arch valances form extensions of the primary structure to the fabricated front bulkhead. The bonnet and boot lids have concealed hinges and both are counterbalanced, the bonnet by a helical spring, and the boot lid by transverse torsion bars. A paint finish is given to the steel facia panel, above which is a shock-absorbent pad, of vacuum-formed p.v.c, backed by moulded polyurethane foam.

To be continued.

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As the name implies, the rollers are of appreciably greater length than diameter; these practically fill the annular space between the two races.

These rollers are domed on their ends when unretained (fig. 1) and trunnion-ended when retained (fig. 2)—this adds slightly to the overall width in many cases.

The pattern using retained rollers is sometimes used to facilitate assembly.

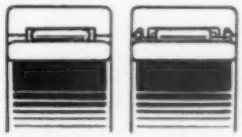

FIG. 1. FIG. 2.

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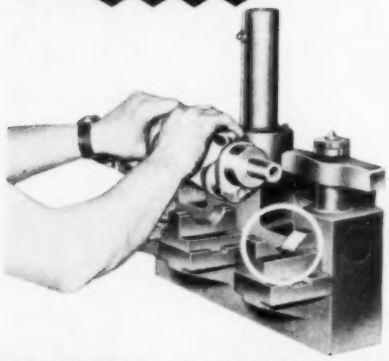

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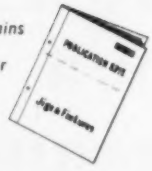

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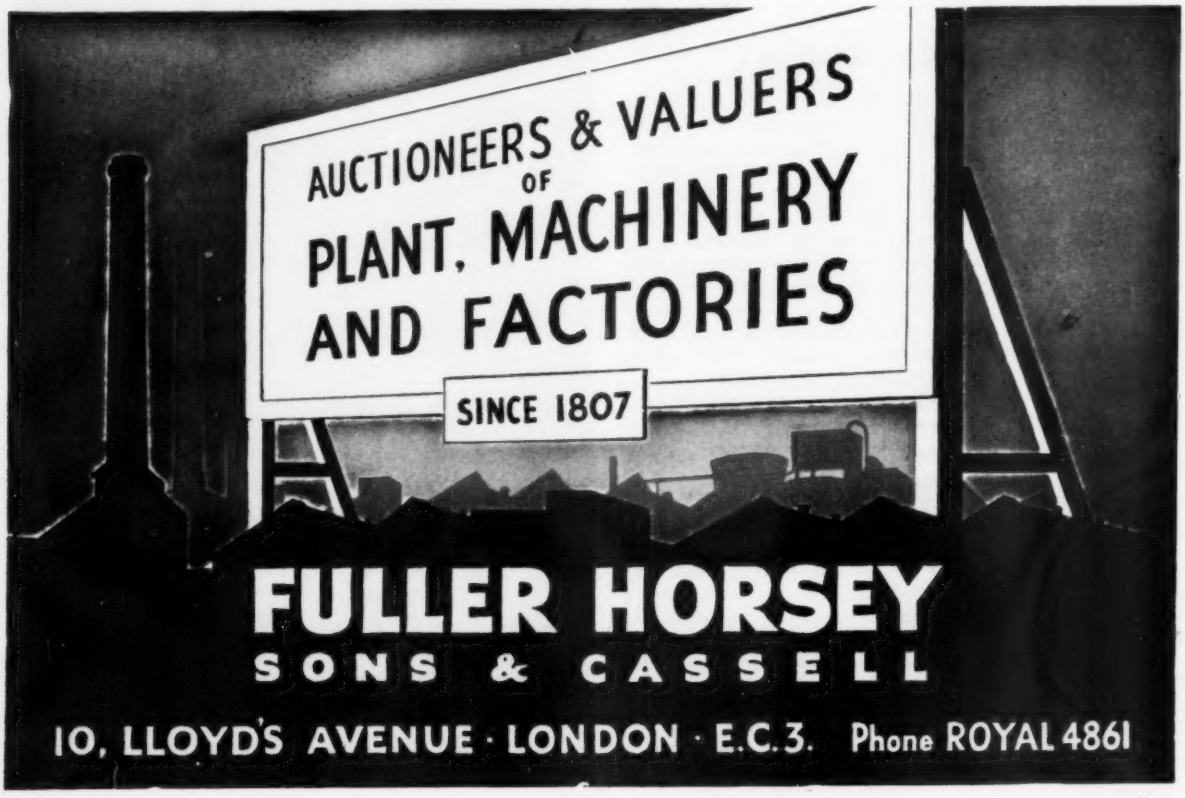

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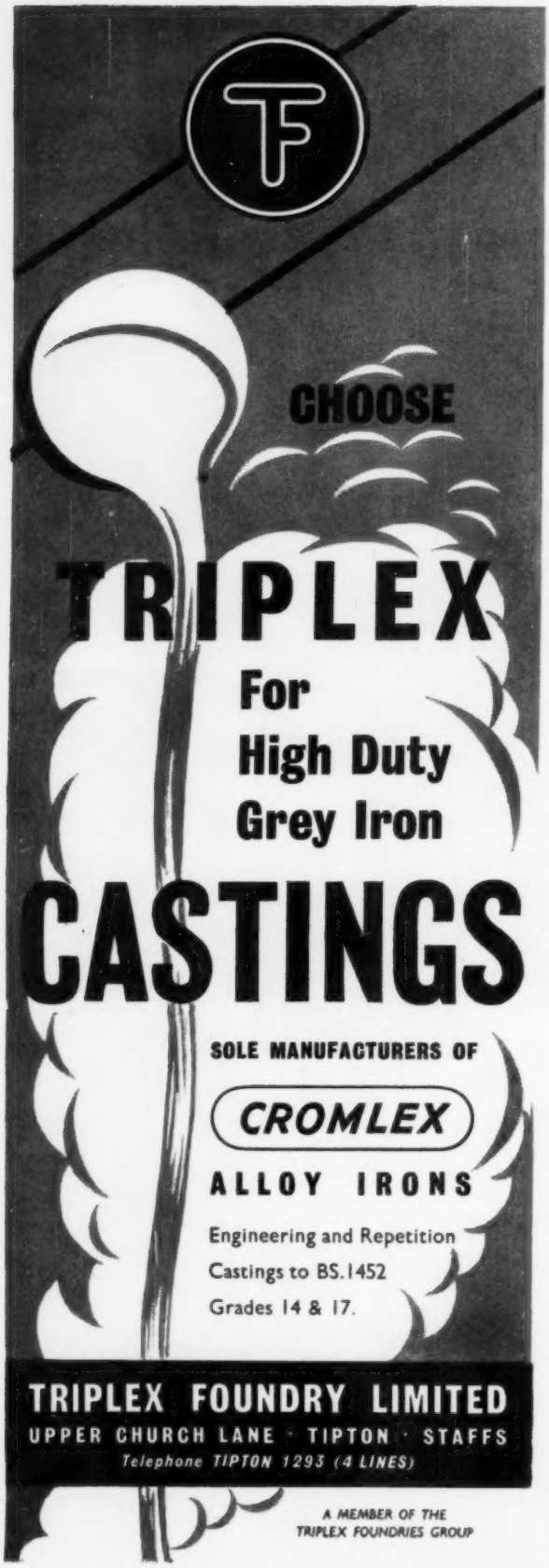

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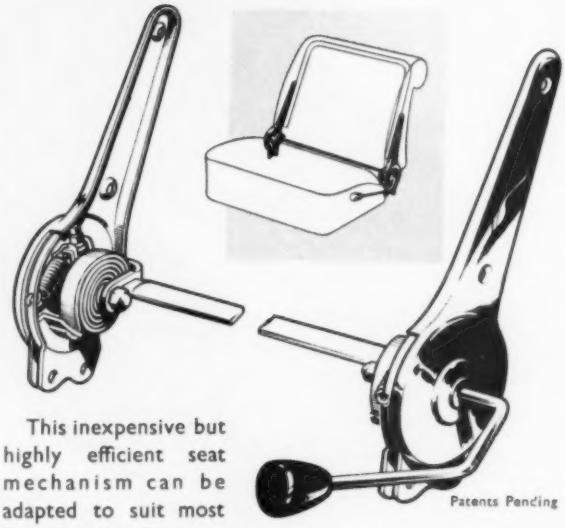

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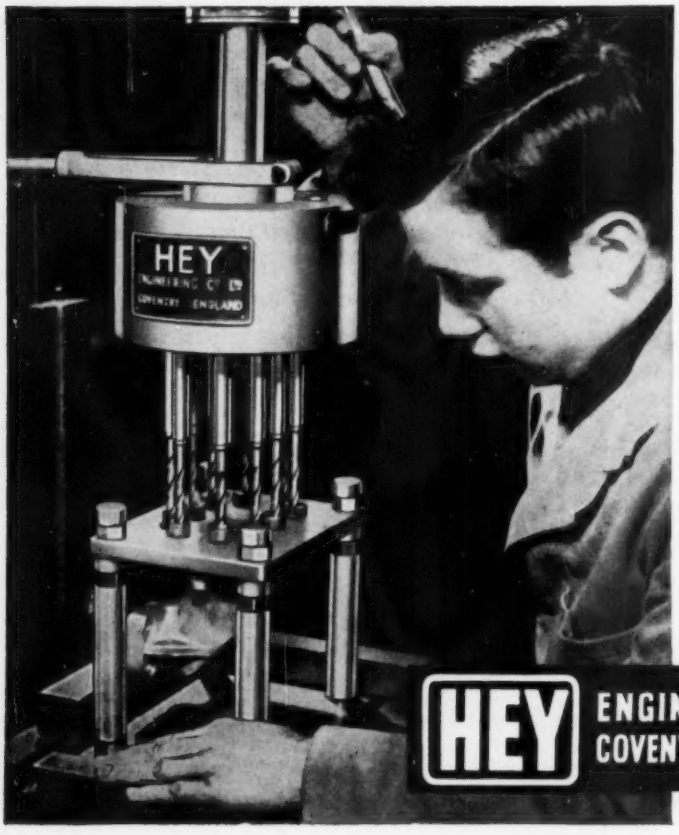

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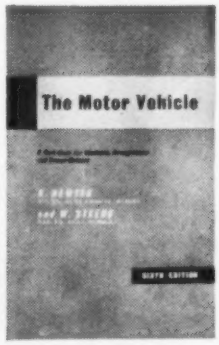

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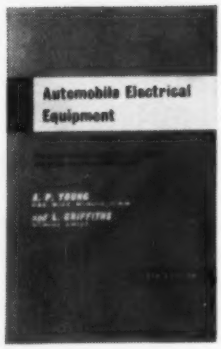

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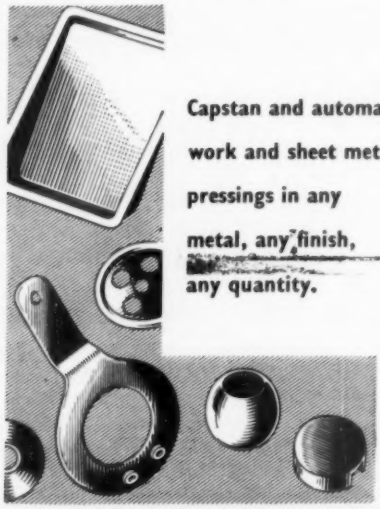

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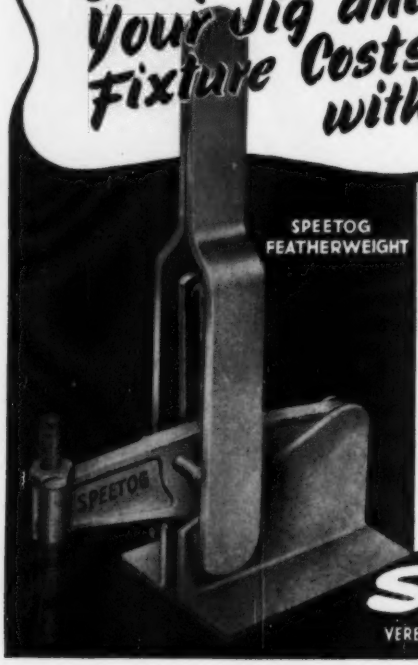

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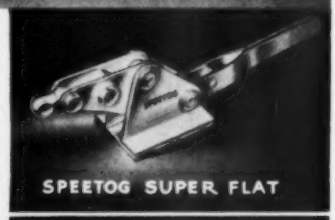
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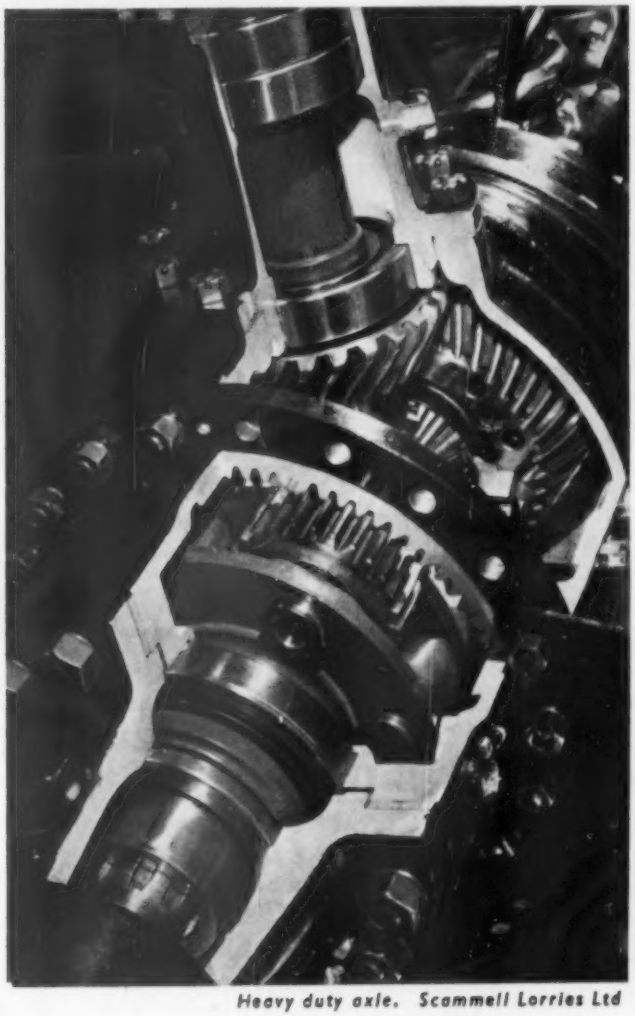

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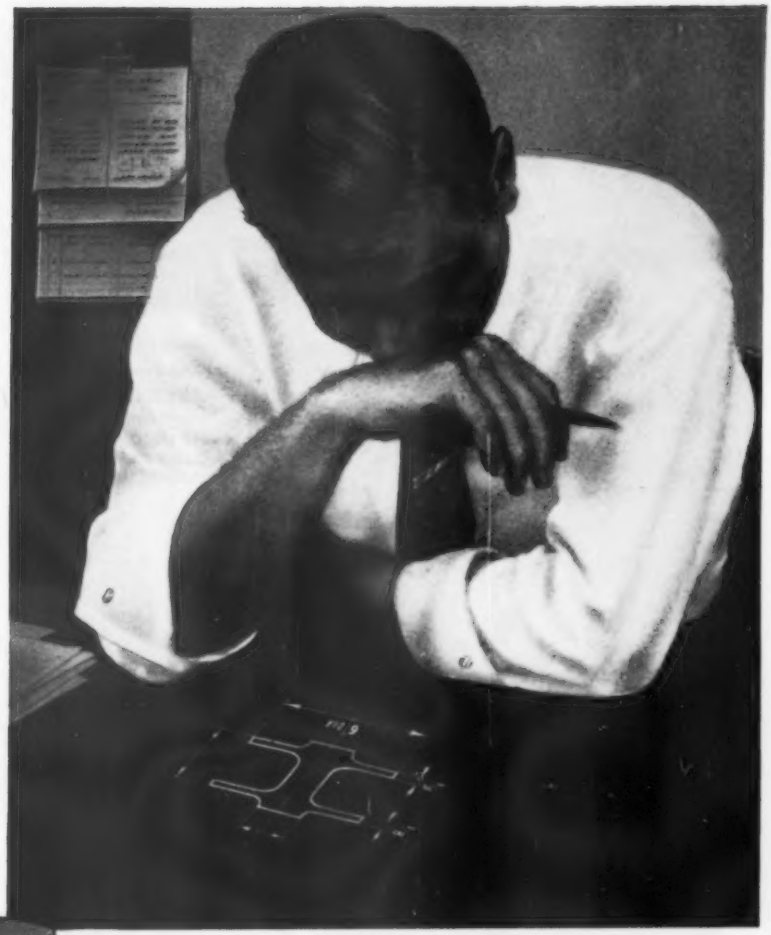

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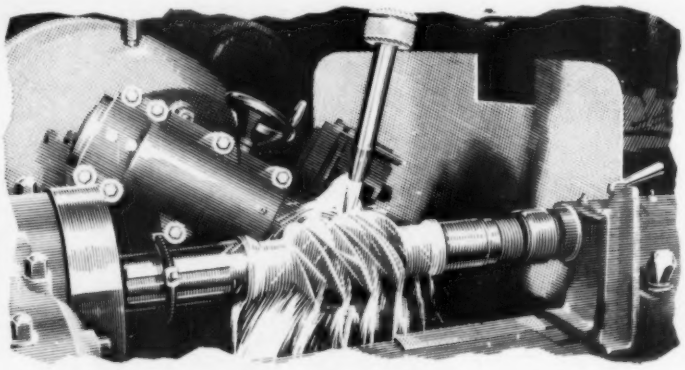

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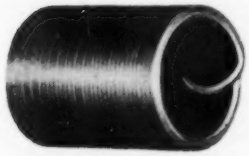

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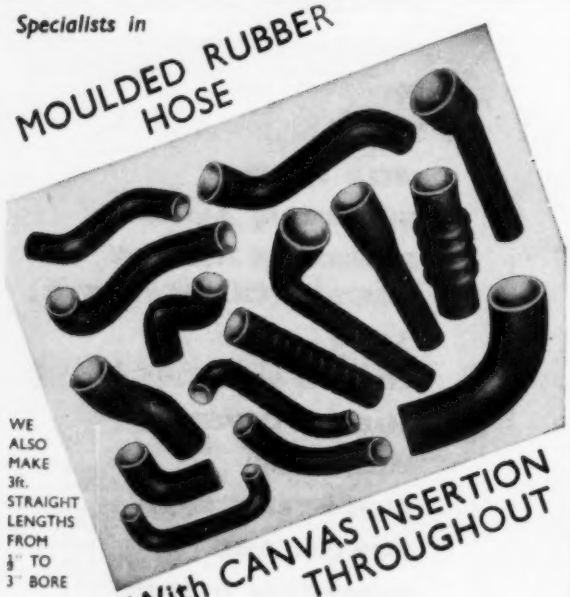

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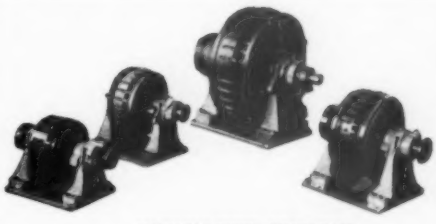

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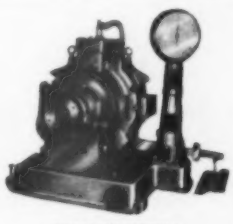

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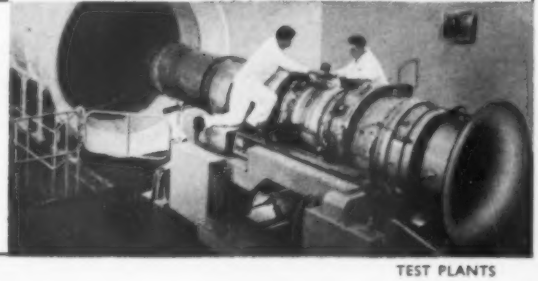

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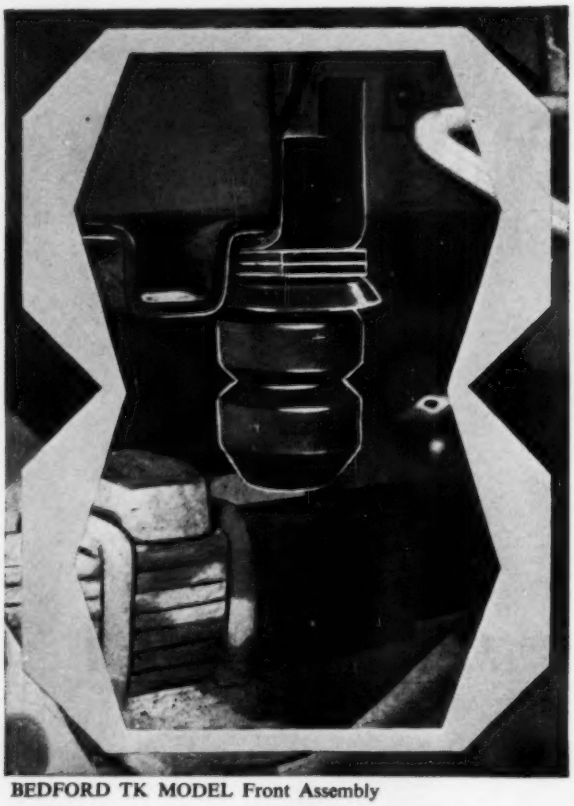

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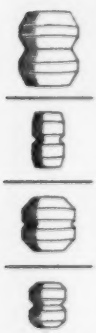

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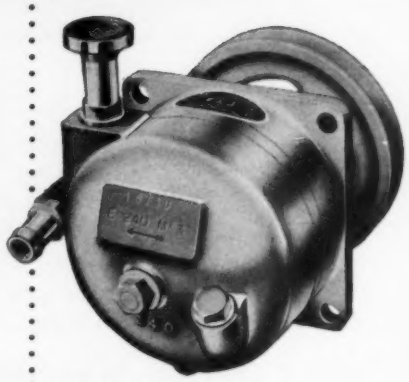

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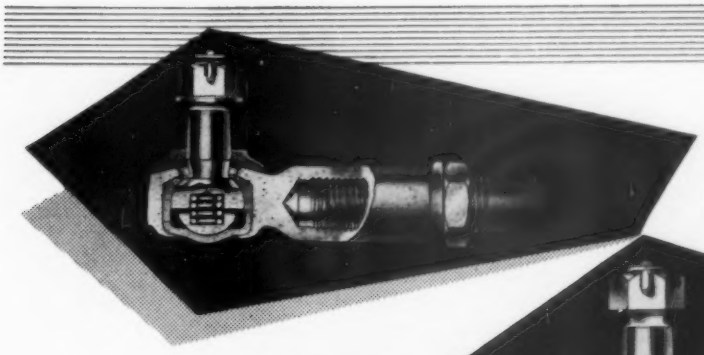

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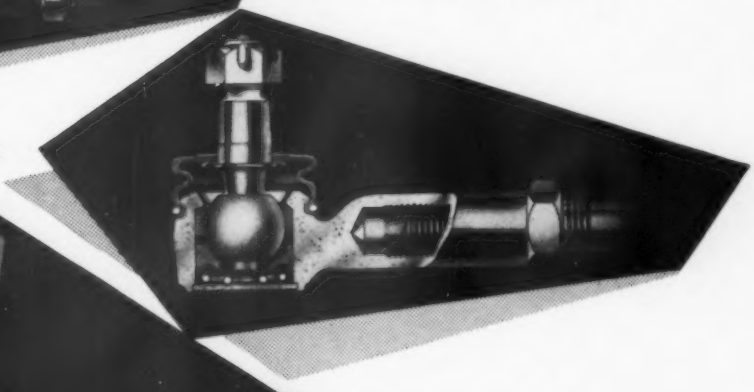

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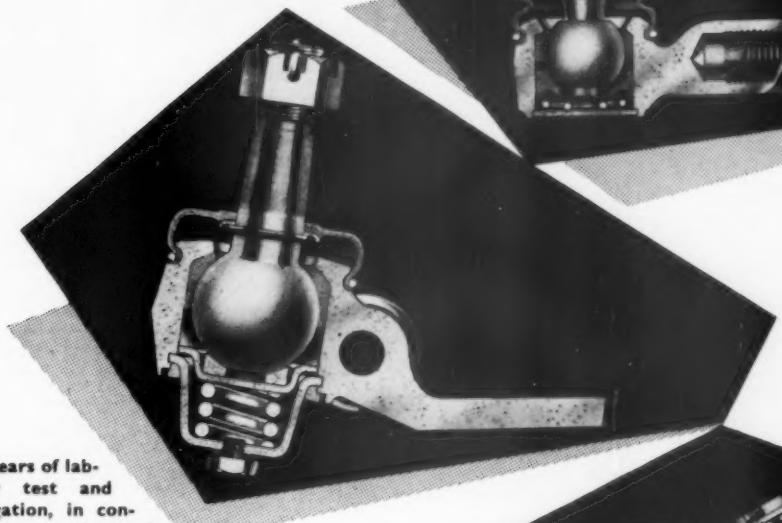

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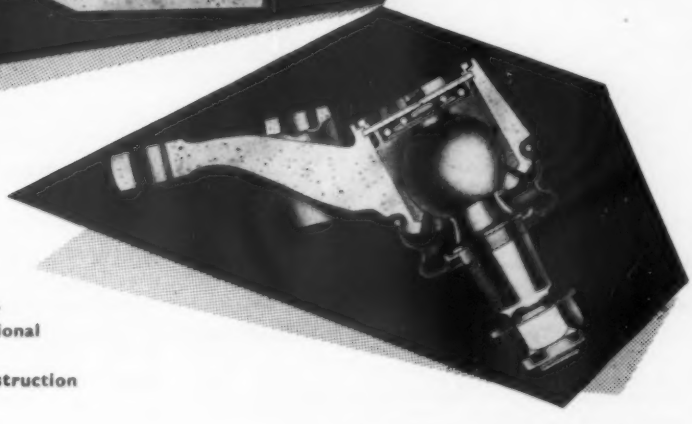

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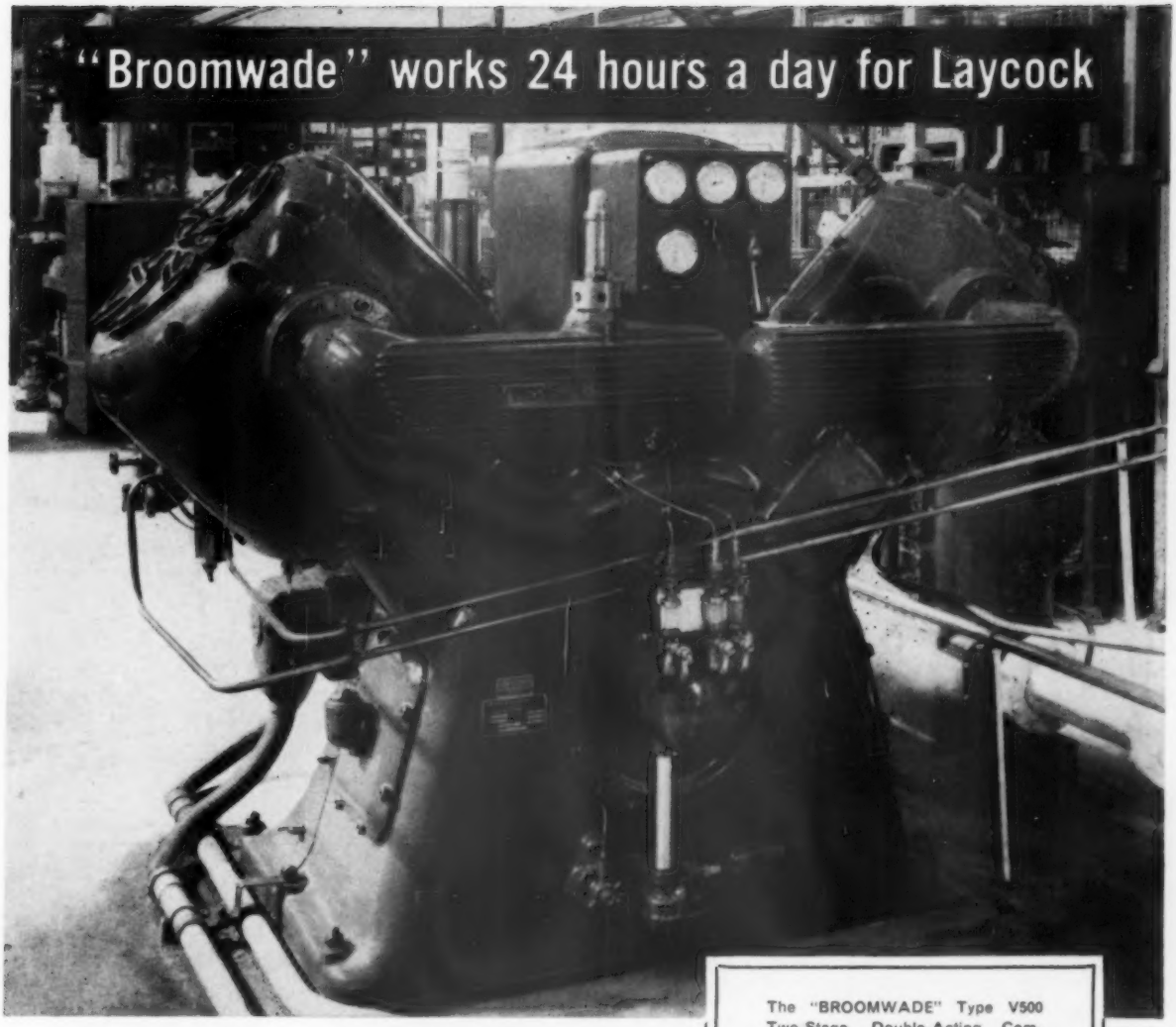

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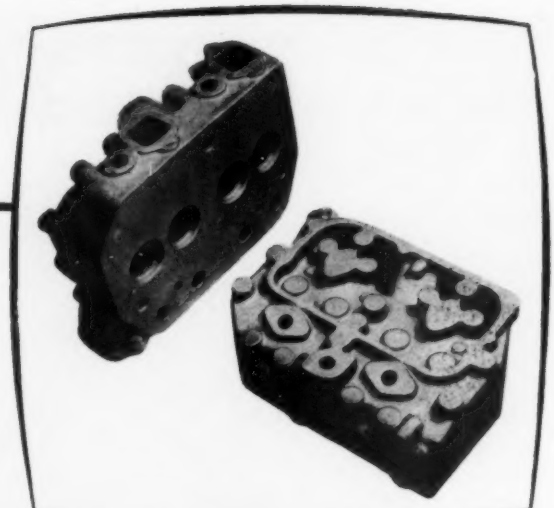

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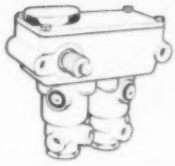

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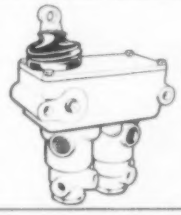

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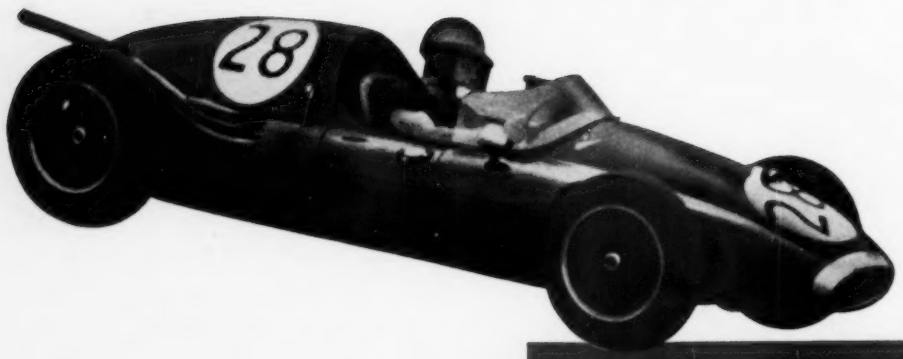

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Coventry Climax FPF series engine
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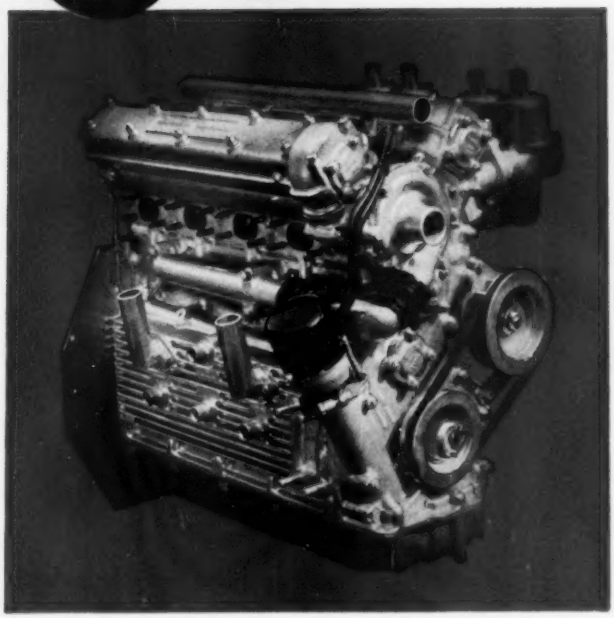

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